A CONCISE COURSE IN

SCIENCE

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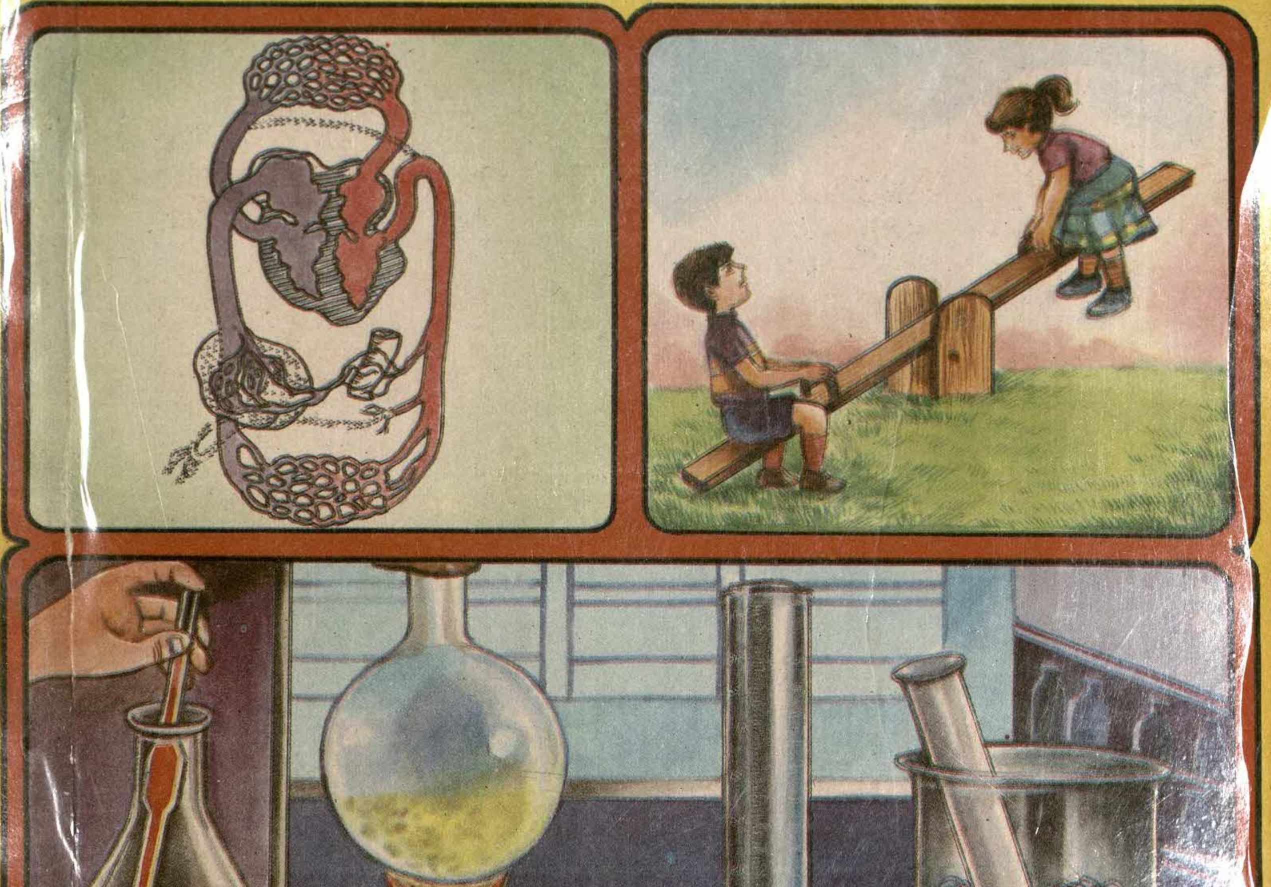

BASED ON THE NEW SYLLABUS IN SCIENCE PREPARED BY N.C.E.R.T., NEW DELHI,
UNDER THE NEW EDUCATION POLICY

A CONCISE COURSE IN SCIENCE

BOOK II

(For Class VII)

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PREFACE

It is considered necessary to initiate a new approach to the study of science at the school vel. At present the emphasis in Science teaching is on the pupil making discoveries by vestigation and on the understanding of the concepts rather than on the memorization of facts.

The new approach to the study of Science demands the active participation of students in e learning process through experimentation. This approach leads to a proper understanding by e students of the basic concepts of Science and enables them to discover new ideas.

The efforts of the authors have been to relate, as far as possible, the teaching of Science to hat a student sees and does in everyday life. The thrill and excitement of doing experiments elp the student to understand the subject and find something new for himself. Students are urious; they search to understand the unknown and so an interest in learning develops. Efforts ave been made here to involve the pupil, physically and emotionally, to make the learning of science a personal experience.

This series has been designed to meet these needs. It fully covers the latest syllabus in science prepared by the N.C.E.R.T. under the New Education Policy. The language used is simple and concise. The text has been attractively illustrated with many clearly labelled diagrams. Carefully planned out questions are given in the text to teach the pupils to reason and to arrive at logical conclusions. A large number of *Objective type* and *Short answer questions* have been included to help the students in self-testing. A number of new diagrams make the matter self-explanatory. The experiments and activities have been carefully designed to fit naturally into their inquiry and are such that every teacher and student can perform without difficulty.

The authors would feel happy if this book could satisfy the needs of the students of the iddle school classes and help them to understand and appreciate the applications of the undamentals of science in everyday life. Suggestions for improvement of this book would be gratefully accepted from fellow science teachers, students and parents.

—*Authors*

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STATES OF MATTER

Molecules

Solids, liquids and gases are made up ticles (tiny bits of matter) called *atoms*. s are so small in size that they are ble with naked eyes. Atoms are further rised of even smaller particles called *ons, protons* and *electrons*. Neutrons rotons are packed together in the nu- or core of the atom. Electrons travel d the nucleus, rather like planets going the sun.

In most substances, atoms are joined er, forming groups called *molecules*. nolecules in a substance remain in a of constant motion.

The haphazard movement of dust par- in a beam of sunlight and the random ment of tiny particles suspended in a a liquid is called *Brownian Movement*.

If you ignite an agarbatti in a corner of n, the fragrant smoke spreads all round om. Soon, one can feel its agreeable . This indicates that the gas molecules have travelled from the agarbatti to nose. Similarly, the smell of food cooked in the kitchen reaches every r of the house.

When we drop an ink tablet in a glass ter, the movement of molecules of a can be seen easily. Ink molecules have ied inter-spaces between the water ules by the process of *diffusion* (Fig.

Diffusion takes place more easily and in gases due to the large inter-spaces en the gaseous molecules.

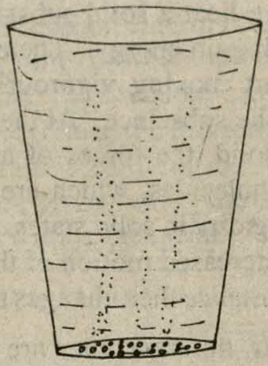

Fig. 1.1. Diffusion of solid in water.

1.2 Forces between molecules–Change of state and effect of heat on molecular arrangement

We have already learnt about three states of matter *i.e.*, solid, liquid and gas. Let us now learn a little more about their change of state.

We know that cubes of ice, on heating, change into water which on further heating becomes steam. As all these are different states of the same substance water, they must have the same kind of molecules ; still why do they have different properties ? This is because of differences in the arrangement of the molecules in solid, liquid and gaseous states of the same substance.

There are forces of attraction between molecules. These forces are not uniform in the three states of a substance. *In a solid substance*, the molecules are held very close to one another by strong attractive forces and the movements of the molecules are limited. Therefore, solid substances are hard and cannot be compressed to a large extent as compared to liquids and gases. This explains why solids have a definite shape and volume.

When we heat a solid substance, the molecules in it gain energy. The energetic molecules start moving vigorously in all directions of the substance. At the melting point of the solid, the forces of attraction between the molecules, which are responsible for the rigidity in solid states are overcome by the increased motion of the molecules. The substance then changes to liquid.

In liquids, the molecules are held together less firmly. Therefore, liquid molecules can be pressed more than solids and take the shape of the container in which they are kept.

In gases, the forces of attraction between molecules are negligible as compared to other states like solids or liquids. Hence, the gaseous molecules have much greater mobility and can be separated widely, from one another.

Gases assume the shape and volume of the container. They can be compressed easily because there is enough space between the molecules.

The molecules of any particular substance are alike, but they differ from the molecules of other substances in size, mass and in a number of other properties (Fig. 1.2).

There are wide gaps or inter-molecular spaces between the molecules of a substance. These gaps are the widest in gaseous molecules, less wide in a liquid and the narrowest in a solid.

A substance may exist as solid, liquid or gas. The form of a substance depends upon the temperature and pressure. Change in temperature can cause changes in the properties of substances.

1.3 Physical Changes

Matter sometimes changes without any re-arrangement of the atoms within a molecule. Such changes are called *Physical Changes.* When ice melts, it goes through a physical change. It turns into water. But this water is made up of the same molecules as those found in ice. In both the cases, each molecule has two hydrogen atoms and one oxygen atom.

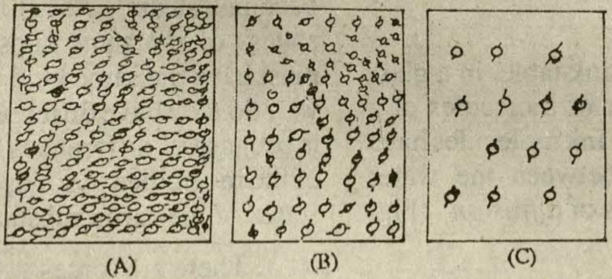

Fig. 1.2 Intermolecular spaces in the three states of matter :

(a) solid state, (b) liquid state and (c) gaseous state.

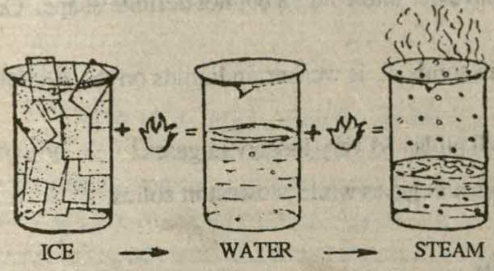

Fig. 1.3 Change of state on heating.

When water boils, another physical change takes place. The water turns into steam. The steam molecules, are still the same as the molecules of water and ice. But the molecules behave differently in each case.

In ice, molecules are tightly bound together by electric forces. Although the molecules make tiny quivering movements all the time, they cannot move around in the solid ice. But when the ice is heated, the molecules quiver faster and faster. Eventually, they break away from their fixed positions and move about. This is the point at which ice melts and becomes water. When the water is heated, the molecules move even faster. In the end, they break away from the other molecules, and move about freely. This happens when water boils.

In solids, atoms or molecules are tightly bound together by forces of attraction.

In liquids, the forces of attraction are less and atoms or molecules are able to slide around.

In gases, attraction is so slight that atoms or molecules move about freely and quickly.

1.4 Movement of Molecules

Put one or two drops of scent on your handkerchief and wave it. Your friend can easily smell the scent at a distance. Why ? This is because the molecules of scent are moving in all directions.

We see dust particles, moving in the beams of sunlight entering a dark room. We find that the movement is constant and haphazard. The visible movement of the particles is due to the fact that the molecules present in air are in a constant state of motion and hence go on hitting the dust particles at random with great speed.

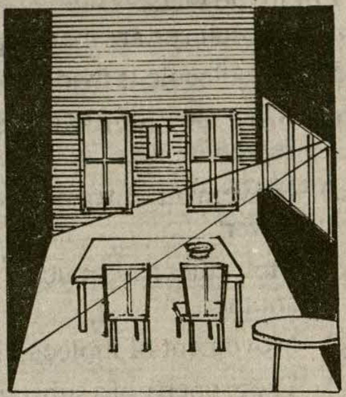

Fig. 1.4 Beam of sunlight entering a dark room.

Since numerous air molecules are constantly bombarding the dust particles from all possible directions, this results in a continuous and irregular motion of the particles. This movement of particles is called *Brownian movement* after the name of the scientist, Robert Brown.

Summary

1. Substances are made up of tiny particles called molecules, which are divided into the simplest invisible particles called atoms.
2. Solids have definite shape and volume. Liquids have definite volume but not definite shape. Gases have neither definite shape nor definite volume.
3. Attraction between the molecules is very strong in solids. It is weaker in liquids on the other hand it is weakest in gases.
4. In solids molecules are tightly packed, loosely in liquids and very loosely in gases.
5. Intermingling of molecules (*i.e.*, diffusion) is fastest in gases while slowest in solids.

Questions

1. Why are substances solids, liquids and gases ?
2. Why do liquids and gases have no fixed shape ?
3. Why do ink tablets colour water?
4. Why do some substances spread smell around?
5. Why do dust particles move in air ?
6. Fill in the blanks :
   (*a*) Substances are made up of tiny particles called ....
   (*b*) A molecule is made up of two or .... than two ....
   (*c*) Movement of molecules from region of higher water concentration to the region of .... concentration is called ....
   (*d*) Movement of water from region of higher water concentration to the region of lower .... concentration is called ....
   (*e*) Molecules have much .... and they get separated widely from one another.
   (*f*) Movement of molecules at random is called ....
   (*g*) The property of a substance to .... its .... after the force ceases to act on it is called ....
   (*h*) Substances which break on applying force are called ....
7. Put a (√) mark against the right statements and (×) mark against the wrong ones :
   (*a*) Solids do not have a fixed shape but have a definite volume.
   (*b*) Liquids and Gases neither have a fixed shape nor a fixed volume.
   (*c*) Movement of molecules at random is called diffusion.
   (*d*) A molecule is made up of two or more than two atoms.
   (*e*) There is no inter-molecular space in liquids.

Activity

Prepare a model of all the three states of matter using clay balls or glass beads.

CHAPTER 2

ELEMENTS, COMPOUNDS AND MIXTURES

Matter

There is a large variety of things all around us. They are all made of matter for example air, water, acids, plants, planets etc. Even we are made of matter. Anything which occupies space and has mass is called *matter*. There are three kinds of matter : *(i) Elements (ii) Compounds* and *(iii) Mixtures*.

2.1 Elements

Elements are *simple* substances. They make up everything in the world. Of the 106 known elements, some, such as Iron and Copper have been used by man since ancient times. Others such as Lawrencium and Mendelevium are man-made. They do not occur in nature.

Substances such as, water and sugar decompose giving simple substances like Oxygen, Hydrogen and Carbon ; which cannot be further divided. Such *simple pure substances* are known as *elements*. Robert Boyle defined an element - "An element in a substance cannot be broken down further into other substances" Molecules of oxygen consist of identical atoms of oxygen only. Therefore, an element can also be defined in the following way :

"A simple substance which is made up of *only one kind of atoms* is called a chemical element" *e.g.*, Carbon = C, Chlorine = Cl, Helium = He etc.

As all written material in English has only 26 letters of alphabet, all the words and sentences that go into producing such a variety of literature are obtained by using different combinations of these 26 letters. Elements combine in different ways to provide a variety of matter such as alphabets combine in different ways to provide a variety of literature.

2.2 Compound

Chemist John Dalton decided to find out how much of each element is needed to form its compounds. He experimented with many combinations and found that he could always mix a couple of elements in any amount, but if he wanted to form an actual compound of the two, they had to be used only in a certain proportion.

For example water, which is a compound of Oxygen and Hydrogen, whenever chemists want to combine these two elements to form water, they find that they must use them in a certain proportion, which is always the same. No matter, whether they are forming a single drop of water or many gallons. They find that each atom of oxygen must hold two atoms of Hydrogen.

"A substance that consists of two, or more than two elements combined together in a fixed ratio is called a compound" *e.g.*, Water = H_2O, Sodium Chloride = NaCl etc.

2.3 Mixtures

Mixture may be defined as "a substance, which is formed by the combination of two or more different substances, exhibiting average properties of the various components.

Milk is a mixture of fat, protein, sugar, water etc. Air is a mixture of Nitrogen, Oxygen, Carbon dioxide, Water vapour etc.

Drinking soda, ice-cream etc., are some common mixtures prepared at home.

From the above discussion we conclude that matter can broadly be divided into three general classes on the basis of properties as follows :

Matter
Pure Substances — Mixtures
Elements — Compounds

2.4 Chemical Reaction

The change that Priestley and Lavoisier observed when they heated mercury was a chemical change. The mercury combined with oxygen from the air to form a new substance called Mercuric oxide. In a chemical change, the chemical properties of a substance are changed and new different substances are formed. The substance or substances formed have properties different from the properties of the materials that combined during the change.

Mercury is a silvery liquid and oxygen is a colourless gas. When combined in a chemical change, they produce a red solid, mercuric oxide.

Fig. 2.1 Antoine Lavoisier (1743—94).

Mercury + Oxygen → Mercuric Oxide

The process in which a substance undergoes a change under certain conditions in which new substances are formed is called *Chemical Reaction.* These changes depend upon the nature of the substance, that is the molecules of which it is made of.

2.5 Decomposition Reaction

Heat Copper carbonate in a boiling tube for a few minutes and observe the changes that occur. Pass the gas through lime water.

We see that when basic Copper carbonate is heated, three new substances are formed — a black solid (copper oxide), a liquid (water) and a gas (carbon dioxide).

$$\text{Copper carbonate} \xrightarrow{\text{Heat}} \text{Copper oxide} + \text{Carbon dioxide} + \text{Water}$$

Here in this case molecules of Copper carbonate are decomposed to form molecules of Copper oxide, Water and Carbon dioxide.

When a substance is decomposed or divided into two or more substances, the process is called *Decomposition Reaction.*

2.6. Combination Reaction

When two or more substances combine together to form new substances, the process is called *Combination Reaction.*

$$\underset{\text{(dark grey)}}{\text{Iron}} + \underset{\text{(yellow)}}{\text{Sulphur}} \xrightarrow{\text{Heat}} \underset{\text{(black)}}{\text{Iron Sulphide}}$$

Mix Iron and Sulphur powder. You will see that there is no chemical change and the elements can be separated with the help of magnet (see Fig. 2.2). Now heat the mixture and observe the change. You will notice that the product of the chemical reac-

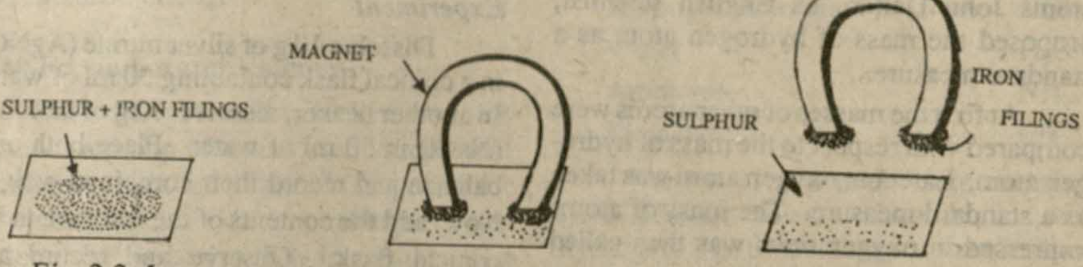

Fig. 2.2 Iron present in a mixture of iron and sulphur is attracted by a magnet.

tion differs from the initial substances (reactants). It has a different colour. It sinks in water without getting separated into Sulphur and Iron. Even iron which was a constituent in the product of the chemical reaction will not be now attracted by a magnet.

The substances sulphur and iron have lost their original properties. A new substance, Iron Sulphide, having its own characteristic properties, is formed.

2.7 Chemical elements and symbols

Scientists have discovered that substances of the world are composed of at least 106 elements. These 106 known elements are the building blocks of matter. As indicated in an earlier section, an element is any substance which in its pure form cannot be separated into simple substances. Mercury and oxygen are both examples of elements as also Gold, Iron, Copper etc.

Most of the elements known today have been discovered directly in nature. A few constituting the remainder have been made by scientists in laboratories. It is quite possible that man will continue to produce new elements. This is an example of the progress of science.

In chemistry, a letter or a group of letters is used to represent an element and it is called a *symbol*. A symbol for an element is either one capital letter or two letters, the first of which is a capital. For example O is the symbol for oxygen , Hg for mercury. Some other elements and their symbols are as follows :

Element	**Symbol**
Sodium	Na
Silver	Ag
Gold	Au
Copper	Cu
Iron	Fe
Calcium	Ca
Potassium	K
Magnesium	Mg
Aluminium	Al
Zinc	Zn
Tin	Sn
Lead	Pb
Mercury	Hg
Hydrogen	H
Silicon	Si
Chlorine	Cl
Bromine	Br
Iodine	I
Nitrogen	N
Phosphorus	P

2.8 Atomic Mass

Different elements have different masses. The lightest atom is hydrogen and the heaviest occurring in a natural form is uranium.

For comparing the masses of different atoms John Dalton, an English scientist, proposed the mass of hydrogen atom as a standard measure.

At first the masses of other atoms were compared with respect to the mass of hydrogen atom. Later on, oxygen atom was taken as a standard measure. The mass of atoms expressed in oxygen units was then called the atomic mass.

The standard has now been changed from oxygen to carbon units.

For purposes ot a standard, the mass of an atom of carbon is taken as 12 and masses of all other atoms are compared with it. The unit for measuring masses of atoms of various elements is called the carbon unit which is $\frac{1}{12}$ th part of the mass of an atom of carbon.

Chemical element	Symbol	Atomic mass in carbon units
Sulphur	S	32
Magnesium	Mg	24
Calcium	Ca	40
Oxygen	O	16

2.9 The Law of Conservation of Mass

In an ordinary chemical change the total mass of the substances that react is equal to the total mass of the products. This is known as the *Law of Conservation of Mass or Matter*. To put it another way, the total amount of matter at the end of a chemical change is equal to the amount of matter at the beginning of the change. Matter is neither created nor destroyed in a chemical reaction.

If a piece of iron rusts, the mass of the iron oxide formed is equal to the mass of the iron atoms plus the mass of oxygen atoms. There is no gain or loss of mass in the chemical change. Similarly, the total mass of the hydrogen atoms and oxygen atoms produced in the electrolysis of water is equal to the mass of the compound water from which these gases are derived.

Experiment

Dissolve 10 g of silver nitrate ($AgNO_3$) in a conical flask containing 50 ml of water. In another beaker, dissolve 10 g of table salt (NaCl) in 50 ml of water. Place both on a balance and record their combined weight. Now, add the contents of the test tube to the conical flask. Observe and record any changes that occur. Place both the conical flask and the empty test tube on the balance and once again record their combined weight. Was any mass gained or lost in the chemical change ?

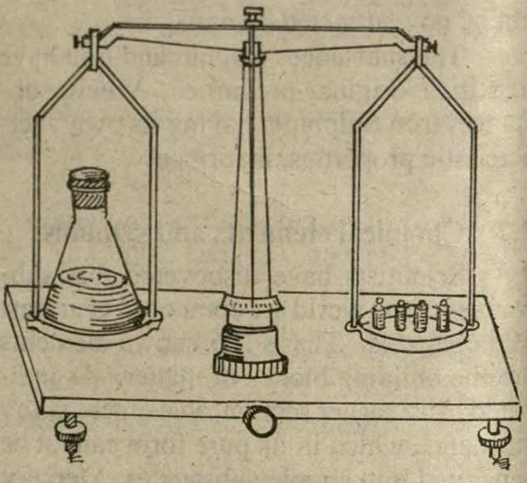

Fig. 2.3 The conical flask contains $AgNO_3$ soln. and the beaker contains NaCl
Weighing the contents of the conical flask after the chemical reaction.

When an ordinary chemical change occurs, there is never a loss of mass.

When coal burns, only a little ash is left. It appears that most of the matter of coal is destroyed. But it is not so. Actually, there is no loss of matter (reactants). If we could weigh the reactants (coal and oxygen) and products (all the ash, soot, water vapour and carbon dioxide), we would find that the total mass of the reactants was the same as the mass of the total products formed through the chemical change.

2.10 Formulae and Valency

As indicated earlier, in chemistry, the letter or a group of letters used to represent an element is called a *symbol*. A symbol for an element is either one capital letter or two letters, the first of which is capital. For example, O is the symbol for oxygen and Hg is the symbol for mercury. In the same manner the molecules of substances are represented by their chemical formulae. In order to determine the chemical formulae of a molecule, it is necessary to know :

(*i*) the chemical elements contained in a molecule of the given substance.

(*ii*) the number of atoms of each element present in the molecule.

From electrolysis of water we get two hydrogen atoms and one oxygen atom.

A molecule of water	→	Two hydrogen atoms	+	One oxygen atom

Therefore the formula for water = H_2O

The ratio by mass in which chemical elements combine to form a compound is always the same. The atoms do not combine with one another in any random ratio. It is on the basis of their characteristics that we express the composition of molecules of substances by means of a formula. Hydrochloric acid is HCl. Similarly H_2 and $CuSO_4$ are the formulae for Hydrogen and Copper Sulphate respectively.

Listed below are the formulae of some compounds of hydrogen :

Hydrogen chloride	...	HCl
Water	...	H_2O
Ammonia	...	NH_3
Methane	...	CH_4

Here we see that different elements have different powers of combining with hydrogen. The combining power of an atom is indicated by *Valency*.

The valency of an element is the number of hydrogen atoms which will combine with or displace the atom of the element.

The formula of a compound tells us the following things :

(*a*) A chemical name of the compound.

(*b*) The components of the compound.

For example, the formula $AgNO_3$ for silver nitrate shows that the compound is made up of three elements Silver, Nitrogen and Oxygen.

(*c*) The ratio in which atoms are combined. For example, the formula $CaC1_2$ shows that calcium and chloride are combined in the ratio of 1 : 2.

(*d*) The molecular mass of the compound. For example, the proportion of magnesium and oxygen by mass in MgO is 1 : 1.

$$Mg + O = MgO$$

The atomic mass of Mg = 24 and that of oxygen = 16.

Therefore the molecular mass of MgO = 24 + 16 = 40.

The formula of H_2SO_4 for sulphuric acid shows that the compound is made up of three elements, Hydrogen, Oxygen and Sulphur.

2.11 Valency of some elements of different compounds

Name of the element	Symbol	Examples of Compound	Valency in the compound
Hydrogen	H	$HC1$, H_2O	1
Sodium	Na	$NaCl$	1
Silver	Ag	$AgCl$	1
Oxygen	O	H_2O, CO_2	2
Magnesium	Mg	MgO	2
Calcium	Ca	CaO	2
Aluminium	A1	$A1_2O_3$	3

2.12 Finding the Valency from Formula

In the molecule of CO_2, the two atoms of oxygen give a total valency of 4 which is balanced by the valency exhibited by an atom of carbon. So carbon has valency 4.

In NaCl (Sodium Chloride) one atom of Sodium combines with one atom of Chlorine and valency of Sodium and Chlorine each is 1.

Iron has valency 3 in Iron Oxide (Fe_2O_3). In another compound of Iron FeO (Ferrous Oxide), Iron shows a valency of 2. So Iron has two valencies of 2 and 3.

The valency of an element is the number of atoms of hydrogen or chlorine combining with one atom of the element.

1. In Aluminium oxide (Al_2O_3), two atoms of aluminium (A1) have combined with three atoms of Oxygen or $3 \times 2 = 6$ valency units, therefore an atom of Aluminium has valency units $\frac{6}{2} = 3$.

Valency of A1 in $AL_2O_3 = 3$.

2. P_2O_5 – P has combined with five atoms of oxygen or $5 \times 2 = 10$ valency units.

1 atom of P $= \frac{10}{2} = 5$ valency units, *i.e*, valency of P in $P_2O_5 = 5$

Valency 1		*Valency 2*	
Ammonium—	NH_4	Carbonate	$-CO_3$
Hydroxide —	OH	Sulphate	$-SO_4$
Nitrate —	NO_3	Sulphite	$-SO_3$

2.13 Chemical equation

Hydrogen + Oxygen → Water

$$2H_2 + O_2 \rightarrow 2H_2O$$

Chemists use an equation to represent chemical changes. An equation is a type of shorthand that describes the atoms and their rearrangement in a chemical reaction. In an equation + is read as 'Plus' and → is read as 'yields' or produces'.

Iron + Sulphur → Iron Sulphide

Water → Hydrogen + Oxygen

The substances to the left of the sign yields in the equation are the starting substances or reactants. The substances to the right of the sign yields are the resulting substances or products.

To change a word equation to a much shorter form, the chemist substitutes formulas and symbols for words. The shorter equation is called a *chemical equation.*

Word equation

Iron + Sulphur → Iron Sulphide

Chemical equation

$$Fe + S \longrightarrow FeS$$

A chemical equation must be balanced. The number of atoms on the left side of the arrow must equal the number of the same atoms on the right side of the arrow. In Iron and Sulphur equation – one atom of Iron and one atom of Sulphur appear on the either side of the sign 'yields'. Therefore, the chemical equation for this reaction between Iron and Sulphur is balanced.

The following chemical equation shows how an unbalanced chemical equation may be balanced.

$$H_2 + O_2 \rightarrow H_2O$$

2 Hydrogen atoms → 2 Hydrogen atoms
+ +
2 Oxygen atoms 1 Oxygen atom

Compare the number and kinds of atoms in this chemical equation.

There are 2 Hydrogen atoms on both sides of this equation. But the equation remains unbalanced because there are 2 oxygen atoms on the left side and only 1 oxygen atom on the right side of the arrow. To balance this equation, $2H_2$ are needed and also $2H_2O$.

Balanced chemical equation

$$2H_2 + O_2 \rightarrow 2H_2O$$

$2 \times 2 = 4$ $2 \times 2 = 4$
Hydrogen atoms Hydrogen atoms
+ $2 \times 1 = 2$
2 Oxygen atoms Oxygen atoms

This equation is balanced because there is an equal number of the same atoms on both sides of the equation. Numbers added to balance an equation are *coefficients*.

Never change a subscription or a formula to balance an equation. Changing a subscript changes the substances. Changing the coefficients changes only the number of molecules of the same substance taking part in the reaction. The balanced chemical equation for the production of water is read : 'Two molecules of hydrogen plus one molecule of oxygen yields two molecules of water'.

Chemical Equations

1. $Fe + O_2 \rightarrow Fe_2O_3$
2. $CaCO_3 + HCl \rightarrow CaCl_2 + H_2O + CO_2\uparrow$
3. $Zn + HCl \rightarrow ZnCl_2 + H_2\uparrow$
4. $Pb(NO_3)_2 \rightarrow PbO + NO_2\uparrow + CO_2\uparrow$
5. $Al_2(SO_4)_3 + Ca(OH)_2 \rightarrow Al(OH)_3 + CaSO_4\downarrow$

Balanced Chemical Equations

1. $4Fe + 3O_2 \rightarrow 2Fe_2O_3.$
2. $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2\uparrow$
3. $Zn + 2HCl \rightarrow ZnCl_2 + H_2\uparrow$
4. $2Pb(NO_3)_2 \rightarrow 2PbO + 4NO_2\uparrow + O_2\uparrow$
5. $Al_2(SO_4)_3 + 3Ca(OH)_2 \rightarrow 2\ Al(OH)_3\downarrow + 3CaSO_4\downarrow$

Use these steps to write chemical equations–

(1) Write a word equation that shows the starting substances and the end products.

(2) Write a chemical equation using symbols and formulas.

(3) If necessary, add coefficients to balance the equation.

(4) Write an upward pointing arrow beside the formula for a product if you know it is a gas.

Examples

(*i*) Water → Hydrogen + Oxygen

$$H_2O \rightarrow H_2 + O_2\uparrow$$

$$2H_2O \rightarrow 2H_2 + O_2\uparrow$$

(*ii*) $Zn + HCl \rightarrow ZnCl_2 + H_2\uparrow$

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2\uparrow$$

Summary

1. Any thing which occupies space and has mass and weight is called matter.
2. There are three forms of matter—elements, mixtures and compounds.
3. Elements are represented by symbols.
4. Atoms of different elements have different masses.
5. Atoms can neither be created nor destroyed in a chemical reaction.
6. During chemical reaction, the masses of reactants and the reaction products remain the same.
7. Chemical elements are represented by these symbols.
8. The molecules of substances are represented by their chemical formula.
9. The ability of an atom of a chemical element to unite with a definite number of atoms of other elements is known as valency.
10. The magnitude of valency is expressed by a whole number.
11. The mode of representing a chemical reaction with the help of formulae is called chemical equation.
12. Chemical equations are written in the form of mathematical equations.
13. This represents the reactants and reaction products by using symbols and formulae.
14. This also represents the amount of the reactants and reaction products in the form of mass or volume.

Questions

1. Why are short names used to represent things ?
2. How many known elements make up the world ?
3. Define element and symbol.
4. Differentiate between elasticity and plasticity.

5. What is decomposition reaction ? Give two examples.

6. What is a chemical reaction ?

7. What is combination reaction ? Give two examples.

8. Define the following :
(*a*) Atom, (*b*) Electrolysis.

9. Give the symbols of the following elements :
Aluminium, Carbon, Magnesium, Copper,
Iron, Sodium, Lead, Potassium, Silver, Gold.

10. State the law of conservation of mass.

11. Why do we use shorthand language ?

12. Why do we see chemical formulae of the various constituents instead of their full names on the labels of medicine bottles ?

13. What do + and → represent in a chemical equation ?

14. Define reactant, product and chemical equation.

15. How is a chemical equation balanced ?

16. What steps are used to write a balanced chemical equation ?

17. Write down the formula for the

(*i*) Hydroxides (*ii*) Copper (*iii*) Ammonium
(*iv*) Sulphates (*v*) Carbonates.

18. Write down the formula for ammonium chloride and ammonium nitrate.

19. Write each of the following as a balanced chemical equation :
(*a*) Carbon + Oxygen → Carbon dioxide
(*b*) Sulphur + Oxygen → Sulphur dioxide
(*c*) Sodium + Chlorine → Sodium chloride
(*d*) Hydrogen + Chlorine → Hydrogen chloride.

20. Fill in the blanks :

(*i*) Chemical reactions in which two or more substances combine together to form a new substance are known as............

(*ii*) Chemical reactions in which two or more new substances are obtained from one substance, are called...........

21 Put a (√) mark against the right statements and a (×) mark against the wrong ones.
(*a*) The compound with the formulae NH_3 is commonly known as Nitrogen Hydride.

( )

(*b*) The formula of Magnesium Chloride is MgCl. ( )

(*c*) In an exothermic reaction, heat is liberated. ( )

(*d*) In an endothermic reaction, heat is absorbed. ( )

Activities

1. Listing elements and writing their symbols.
2. Writing formulae of simple compounds using symbols of elements.

□□

CHAPTER 3

ACIDS, BASES AND SALTS

3.1 Oxides

When elements are burnt in oxygen, *oxides* are formed.

For example, when carbon, sulphur, magnesium and sodium burn in oxygen, oxides are formed.

Some oxides are acidic and some are basic in nature.

(*i*) Acidic Oxides.

These are oxides which are soluble in water, turn blue litmus red and react with bases to form salts and water. *Generally, non-metals form acidic oxides.*

$$CO_2 + H_2O \rightarrow H_2CO_3 \text{ (Carbonic acid)}$$

$$\underset{\text{(Acidic oxide)}}{CO_2} + \underset{\text{(Base)}}{2NaOH} \rightarrow \underset{\text{(Salt)}}{Na_2CO_3} + \underset{\text{(Water)}}{H_2O}$$

$$\underset{\text{(Acidic oxide)}}{SO_2} + \underset{\text{(Base)}}{2NaOH} \rightarrow \underset{\text{(Salt)}}{Na_2SO_3} + \underset{\text{(Water)}}{H_2O}$$

(*ii*) Basic Oxides.

These oxides, if soluble in water, turn red litmus blue and react with acids to form salt and water. *Generally, metals form basic oxides.*

$$\underset{\text{(Basic oxide)}}{CaO} + \underset{\text{(Water)}}{H_2O} \rightarrow \underset{\text{(Base)}}{Ca(OH)_2}$$

$$\underset{\text{(Basic oxide)}}{CaO} + \underset{\text{(Acid)}}{2HCl} \rightarrow \underset{\text{(Salt)}}{CaCl_2} + \underset{\text{(Water)}}{H_2O}$$

$$\underset{\text{(Basic oxide)}}{MgO} + \underset{\text{(Water)}}{H_2O} \rightarrow \underset{\text{(Base)}}{Mg(OH)_2}$$

$$\underset{\text{(Basic oxide)}}{MgO} + \underset{\text{(Acid)}}{H_2SO_4} \rightarrow \underset{\text{(Salt)}}{MgSO_4} + \underset{\text{(Water)}}{H_2O}$$

(*iii*) Amphoteric Oxides.

The oxides which react both with acids as well as bases to form salt and water are called *amphoteric oxides* ; for example, Aluminium oxide (Al_2O_3), Zinc oxide (ZnO) etc.

3.2 Acids

Chemical reactions often involve one or more acids. Acids are chemical compounds that have common characteristics.

Acids have some common properties :

(*i*) have a sour taste,
(*ii*) turn blue litmus red,
(*iii*) turn methyl orange red,
(*iv*) corrode metals,
(*v*) react with a base to form salt and water,
(*vi*) normally contain Hydrogen,
(*vii*) corrosive in nature, and
(*viii*) react with metals, metal oxides and metal carbonates.

An acid is a compound when dissolved in water has hydrogen available, which can be replaced by a metal to form a salt.

Experiment.

Obtain some buttermilk, vinegar, lemon juice and soda water. Taste a small amount of each liquid. Test each liquid with a piece of blue litmus paper. It is red when it is in contact with an acid and blue when in contact with a base.

Each of the buttermilk, vinegar and lemon juice contains an organic acid. Buttermilk contains lactic acid, vinegar contains acetic acid and lemon juice contains citric acid. Each of these organic acids is composed of Carbon, Hydrogen and Oxygen.

Soda-water contains Carbonic acid (H_2CO_3). What are the three elements present in this compound ? Carbonic acid is produced by dissolving carbon dioxide gas in water under high pressure.

$$\underset{\text{(Carbon dioxide)}}{CO_2} + \underset{\text{(Water)}}{H_2O} \rightarrow \underset{\text{(Carbonic acid)}}{H_2CO_3}$$

Open a bottle of water soda and you will see bubbles pop which are escaping gas. The bubbles are carbon-dioxide gas which escape when the pressure is reduced by removing the bottle cap.

$$\underset{\text{(Carbonic acid)}}{H_2CO_3} \rightarrow \underset{\text{(Carbon dioxide)}}{CO_2} + \underset{\text{(Water)}}{H_2O}$$

How is this reaction different from the chemical change shown in the previous equation ?

Table 1 Some Common Acids

Acid	*Formula*
Carbonic acid	H_2CO_3
Hydrochloric acid	HCl
Nitric acid	HNO_3
Sulphuric acid	H_2SO_4
Acetic acid	CH_3COOH
Hydrofluoric acid	HF

Each acid contains hydrogen. It is conventional for chemists to write the hydrogen first in the formula for an acid. When acids react with many metals, hydrogen gas is formed *e.g.*, when dilute sulphuric acid is added to zinc metal hydrogen gas is released.

Thus the definition of an acid radical is :

"*An acid is a compound whose molecules contain atom or atoms of Hydrogen.* An atom or a group of atoms which acts as a unit is called an acid radical."

$$\underset{\text{(Zinc)}}{Zn} + \underset{\text{(Sulphuric Acid)}}{H_2SO_4} \rightarrow \underset{\text{(Zinc Sulphate)}}{ZnSO_4} + \underset{\text{(Hydrogen)}}{H_2}$$

$$\underset{\text{(Iron)}}{Fe} + \underset{\text{(Hydrochloric acid)}}{2HCl} \rightarrow \underset{\text{(Iron Chloride)}}{FeCl_2} + \underset{\text{(Hydrogen)}}{H_2}$$

$$\underset{\text{(Magnesium)}}{Mg} + \underset{\text{(Acetic acid)}}{2CH_3COOH} \rightarrow \underset{\text{(Magnesium Acetate)}}{Mg\,(CH_2COO)_2} + \underset{\text{(Hydrogen)}}{H_2}$$

A. Hydrochloric Acid (HCl)

We know when acids react with many metals, hydrogen gas is formed.

$$\underset{\text{(Zinc)}}{Zn} + \underset{\text{(Hydrochloric acid)}}{2HCl} \rightarrow \underset{\text{(Zinc Chloride)}}{ZnCl_2} + \underset{\text{(Hydrogen)}}{H_2}$$

Take a few ml. of hydrochloric acid in a test tube. Take another tube which contains water only. Put one drop of acid into this tube with the help of a dropper. Just taste this water, then test with blue and red litmus.

You will observe that Hydrochloric acid solution is a colourless liquid which has a pungent smell and some taste. It changes the colour of blue litmus to red but it does not change the colour of red litmus. Calcium oxide dissolves in hydro-chloric acid.

$$\underset{\text{(Calcium oxide)}}{CaO} + \underset{\text{(Hydrochloric acid)}}{2HCl} \rightarrow \underset{\text{(Calcium Chloride)}}{CaCl_2} + \underset{\text{Water}}{H_2O}$$

Calcium carbonate forms carbon dioxide gas with hydrochloric acid.

$$\underset{\text{(Calcium Carbonate)}}{CaCO_3} + \underset{\text{(Hydrochloric acid)}}{2HCl} \rightarrow \underset{\text{(Calcium chloride)}}{CaCl_2} + \underset{\text{(Water)}}{H_2O}$$

Calcium carbonate forms carbon dioxide gas with hydrochloric acid.

$$\underset{\text{(Calcium Carbonate)}}{CaCO_3} + \underset{\text{(Hydrochloric acid)}}{2HCl} \rightarrow \underset{\text{(Calcium Chloride)}}{CaCl_2} + \underset{\text{(Water)}}{H_2O}$$

$$+ \underset{\text{(Carbon dioxide)}}{CO_2}$$

B. Sulphuric Acid (H_2SO_4)

Take a hard glass test tube half full of water. Pour a few drops of concentrated

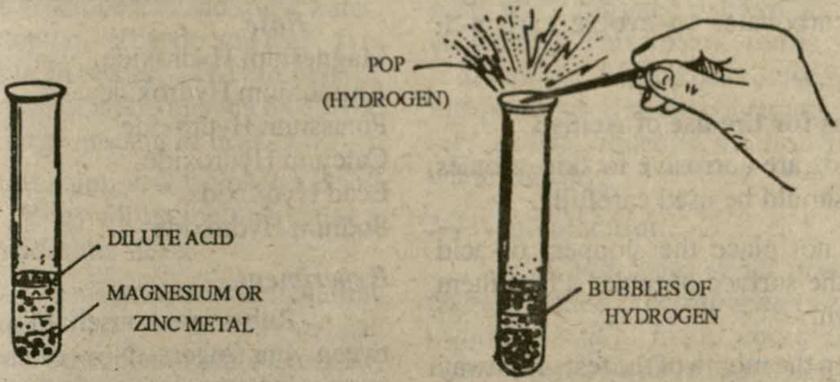

Fig. 3.1 (Left) Reaction of an acid on a metal (magnesium or zinc)
(Right) Testing the gas from an acid and a metal.

sulphuric acid and gently shake the test tube. Is there any change in temperature? It dissolves readily in water with the evolution of heat.

You must take the precaution that concentrated sulphuric acid is always diluted with water by pouring a thin stream of the acid in well stirred water. Water is never to be poured on the acid kept in a vessel. During dissolution, great heat is liberated. Since water is liquid like sulphuric acid, the hot water remains above the acid. It may even boil and splash the acid causing injury.

Now put a drop of this acid solution on the red and blue litmus paper.

We will notice that it changes the colour of the blue litmus to red.

Like hydrochloric acid it reacts with zinc and forms hydrogen gas.

$$\underset{\text{(Zinc)}}{Zn} + \underset{\text{(Sulphuric acid)}}{H_2SO_4} \rightarrow \underset{\text{(Zinc sulphate)}}{ZnSO_4} + \underset{\text{Hydrogen}}{H_2}$$

With carbonates and washing soda it evolves carbon dioxide gas.

In a pure state it is a colourless and a heavy liquid. It is nearly twice as heavy as water. Commercial samples have a slight brown colour due to impurities. It must be used cautiously as it is highly corrosive. Any person who gets acid on his body or clothing should flush the acid away immediately with a lot of water. If available, baking soda or milk of magnesia should be applied at once to the affected part. Baking soda and milk of magnesia neutralize acids and destroy their harmful properties.

(C) Nitric acid

Take a few ml. of nitric acid in a test tube. Observe its colour and smell it from a distance.

You will find that in a pure state it is colourless. But you will notice nitric acid bottles are brown coloured. This is due to the presence of nitrogen dioxide, which is brown. Nitrogen dioxide is formed by the decomposition of nitric acid.

Pour a few ml. of nitric acid in a test tube half filled with water. Now taste their solution and put one drop of dilute nitric acid on red and blue litmus paper. It dissolves readily in water and does not liberate heat when it is diluted with water. It has some taste and turns blue litmus red. It has no effect on red litmus.

When touched by hand, it produces yellow stain on the skin. It also reacts with metals with the liberation of hydrogen gas and with carbonates to evolve carbon-di oxide gas.

Precautions for the use of Acids :

1. Acids are corrosive to skin, clothes etc. They should be used carefully.

2. Do not place the stoppers of acid bottles on the surface of table. Place them upside down.

3. Keep the mouth of the test tube away from yourself and your neighbour while heating a solution of an acid in a test tube.

4. To dilute an acid, it must be poured slowly into water. Never pour water into conc. acid.

3.3 Bases

Several kinds of bases are found in common household products. Ammonia, Caustic Soda and milk of magnesia are a few examples of bases. A base is also known as *antacid* or *alkali*. Milk of magnesia is the common name for magnesium hydroxide, an effective laxative and its formula is $Mg(OH)_2$

The ammonia commonly used in the home is a solution of ammonia gas (NH_3) in water. This ammonia solution has a chemical formula NH_4OH. The chemical name for caustic soda is sodium hydroxide ($NaOH$).

Many bases contain oxygen and hydrogen. The symbol for these two elements are grouped in the formula for a base as OH. Some bases contain more than one group.

"A base is a compound which reacts with an acid to give a salt and water and no other product."

Table 2. Some Common Bases

Base	*Formula*
Magnesium Hydroxide	$Mg(OH)_2$
Ammonium Hydroxide	NH_4OH
Potassium Hydroxide	KOH
Calcium Hydroxide	$Ca(OH)_2$
Lead Hydroxide	$Pb(OH)_2$
Sodium Hydroxide	$NaOH$

Experiment.

Rub some household ammonia between your fingers. Now rub some milk of magnesia between your fingers. Now put a piece of red litmus paper in each liquid. Record any change in colour that you observe. Red litmus is used as a test for a base because bases cause litmus to turn from red to blue. In separate containers of water, dissolve some soap and some lime (CaO). Test each of these solutions with red litmus paper. Identify the solution.

Bases have some common properties :

(*i*) Have a bitter taste.
(*ii*) Feel slippery when rubbed between the fingers.
(*iii*) Dissolve fats and oils.
(*iv*) Turn red litmus blue, methyl orange yellow.
(*v*) Destroy the properties of acid.
(*vi*) Contain hydrogen, oxygen and atleast one metal.

Those bases are compounds whose molecules consist of atoms of metal connected with one or more hydroxyl (OH) groups.

A. Caustic Soda (NaOH)

Place a piece of sodium hydroxide on a watch glass (Do not touch with hands. Use a pair of tongs or forceps.) and leave it aside for sometime. You will notice that it absorbs moisture from air.

Now take some sodium hydroxide crystals in the test tube and add some water. Touch the test tube. What do you feel? It is readily soluble in water. The process of dissolution in water is accompanied with the evolution of large amount of heat.

Touch this solution with your hand and also taste it. You will notice that it has a soapy touch and bitter taste.

Divide this sodium hydroxide solution in two parts. In the 1st part add blue and red litmus and to the other phenolphthalein solution. You will see that it changes the colour of the red litmus blue and colourless phenolphthalein to pink.

If sodium hydroxide solution falls on the skin or the clothes, the affected part should be immediately washed with water several times.

It is also known as caustic soda used in industries like soap manufacture, petroleum refining, textile production and plastics, etc. It is a very strong base and dissolves oil and grease readily. It is often used to unclog sink drains.

B. Calcium Hydroxide $Ca(OH)_2$

Place a piece of calcium hydroxide on a watch glass and leave it aside for some time. You will find it hydroscopic.

Now take some calcium hydroxide in a test tube and add water. Stir it with a glass rod. Does it dissolve in water? It is sparingly soluble in water. *An aqueous solution of calcium hydroxide is called lime water.* Pass carbon dioxide gas through lime water. It turns milky.

$$\underset{\text{(Calcium hydroxide)}}{Ca(OH)_2} + \underset{\text{(Carbon dioxide)}}{CO_2} \rightarrow \underset{\text{(Calcium Carbonate)}}{CaCO_3} + \underset{\text{(Water)}}{H_2O}$$

Take the supernatent liquid in two test tubes. Test one with litmus paper and in other pour few drops of phenolphthalein and note down the changes.

By hydration of quick lime (CaO) a pasty white substance, slaked lime $Ca(OH)_2$ is obtained. This lime is used as disinfectant in drains, etc. Slaked lime is used for preparing mortar used in the construction of buildings and its aqueous solution is used for white washing.

3.4 Neutralization

Acid and bases react in a chemical change called neutralization to produce water and a salt. In the process of neutralization, the properties of both the acid and the base are destroyed, resulting in a mixture of water and a salt that is said to be *neutral.* Neutral means that a substance is neither an acid nor a base. Thus, neither the water nor the salt affects the colour of red litmus or blue litmus.

When hydrochloric acid and sodium hydroxide are mixed, a chemical change occurs. Its products are water and salt.

$$\underset{\text{(Hydrochloric acid)}}{HCl} + \underset{\text{(Sodium hydroxide)}}{NaOH} \rightarrow \underset{\text{(Water)}}{H_2O} + \underset{\text{Sodium chloride)}}{NaCl}$$

The presence of an acid or a base and their neutralization point may be shown with an indicator. An indicator is a substance used to show, usually by a colour change, the presence of an acid, base or other substance in a solution. Litmus paper and phenolphthalein are two common indicators. Phenolphthalein turns red in a base and is colourless in an acid.

The following examples of neutralization indicate the acid, the base and the salt in each equation.

(1) $HNO_3 + KOH \rightarrow KNO_3 + H_2O$
(Potassium nitrate)

(2) $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$
(Sodium sulphate)

(3) $HCl + KOH \rightarrow KCl + H_2O$
(Potassium chloride)

3.5 Salts

A substance formed by the neutraliza-

tion reaction of an acid with a base is called salt.

Sodium chloride (NaCl) is only one of the class of compounds called salts. There are a great number of salts. Their compounds have many different properties. However, all the salts are alike in that a salt contains at least one metal and one non-metal.

Thus a salt can be defined as a compound which can be formed by replacing the hydrogen of an acid with a metal. A few examples are given below :

	Reactants	**Name of salt formed**
1.	Zn and HCl	$ZnCl_2$ (Zinc Chloride)
2.	NaOH and HNO_3	$NaNO_3$ (Sodium Nitrate)
3.	$Ca(OH)_2$ and CO_2	$CaCO_3$ (Calcium Carbonate)

Metallic zinc reacts with dilute hydrochloric acid.

$$\underset{\text{(Zinc)}}{Zn} + \underset{\text{(Hydrogen chloride)}}{2HCl} \rightarrow \underset{\text{(Zinc chloride)}}{ZnCl_2} + \underset{\text{(Hydrogen)}}{H_2}$$

Common salt is an essential constituent of diet. It is also used as a preservative. It is mixed with ice to get the freezing mixture. It is also used in the manufacture of chlorine, hydrochloric acid, washing soda, soap, etc.

Sodium carbonate is used in laundry, while sodium bicarbonate in baking powder and also in fire extinguishers. Copper sulphate is used as a fungicide, in dyeing, calicoprinting, medicines, etc.

3.6 Soaps and Detergents

The making of soap is an excellent example of a chemical reaction in which the product is a very useful substance. Soap is the product of a chemical reaction between sodium hydroxide (NaOH) and fat.

Fat + Sodium hydroxide → Glycerine + Soap

The soap manufacturing is a long chain of bonded atoms. The properties of soap depend on whether plant or animal fat is used and whether sodium hydroxide or potassium hydroxide is used. Sodium soaps are hard soaps, and potassium soaps are soft or liquid soaps. When you wash a greasy frying pan with soapy water the soap "cuts" the grease. By rinsing the pan you wash away the grease and soapy water.

A *detergent* is a cleaning substance. Synthetic detergents are man-made chemical compounds that have a cleansing action similar to soap. Their great advantage is that they work very well in hard water as they do in soft water.

Soaps and detergents are of one common use. We use them for cleaning our bodies, clothes and utensils, etc. Soaps and detergents are also being used in laundry, textile industry, shaving soaps, shampoos, water proofing cement, etc.

Efflorescence and Deliquescence

In some cases, hydrated salts lose their water of crystallization in the atmosphere at normal temperature ; this is called *efflorescence.*

e.g., — $Na_2CO_3 . 10\ H_2O$.

Some substances absorb water from the atmosphere and form saturated solutions. This is called *deliquescence*

e.g. — $Zn\ (NO_3)_2$. NaOH.

Preparation of Carbon dioxide and Study its properties

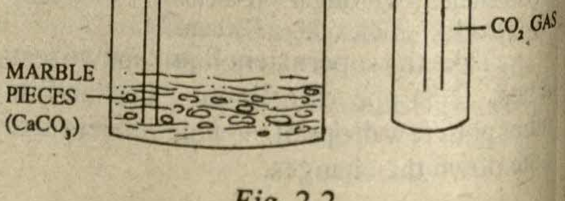

Fig. 2.2

Reaction

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$$

Put some marble chips in the Woulf's bottle fitted with the delivery tube and a thistle funnel. Put some water so as to cover the marble pieces. Now put conc. HCl through the mouth of the thistle funnel. Collect the gas by upward displacement of air.

Properties

(1) CO_2 is a colourless gas with no smell.

(2) Introduce a burning match stick into the gas jar — it extinguishes. It shows that CO_2 is neither combustible nor a supporter of combustion. So it is used in fire extinguishers.

3) Invert a jar full of CO_2 in a trough of water. It rises which shows this gas is soluble in water.

4) Put few drops of blue litmus into the jar of CO_2. It changes to red. The change in colour clearly indicates it is acidic in nature

$$H_2O + CO_2 \rightarrow H_2CO_3.$$

5) Put few drops of limewater — It changes milky which shows it forms insoluble calcium carbonate

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O.$$

Summary

1. Oxides are formed when metals and non-metals are burnt in air.
2. Some oxides are acidic and some oxides are basic.
3. The oxides of non-metals (Co_2, SO_2) are acidic in nature.
4. The oxides of metals (CaO, MgO) are basic in nature.
5. With water acidic oxides give acids but basic oxides give alkalies.
6. Acidic and Basic oxides react with alkalies and acids respectively to give salt and water.
7. The oxides which react both with acids as well as bases to form salt and water are called amphoteric oxides.
8. Acids are chemical compounds that have common characteristics :
   - (*i*) Sour in taste,
   - (*ii*) Turn blue litmus red,
   - (*iii*) Turn Methyl orange red,
   - (*iv*) Corrode metals, and
   - (*v*) Contain only non-metals, and
9. All acids contain hydrogen atoms in their molecules *e.g.*, HCl, H_2SO_4, HNO_3 etc.
10. Bases are oxides and hydroxides of metal. Bases which dissolve in water form alkalies. They have common characteristics :
    - (*i*) Have a bitter taste,
    - (*ii*) Found slippery when rubbed between the fingers,
    - (*iii*) Dissolve fats and oils,
    - (*iv*) Turn red litmus blue,
    - (*v*) Turn methyl orange yellow.

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11. When alkalies react with acids, salt and water are formed. This reaction is known as neutralization.
12. A substance formed by the neutralization reaction of an acid with a base is called salt.
13. Common salt is an essential constitutent of our diet.
14. Efflorescent substances lose water of crystallization on exposure to the atmosphere whereas deliquescent substances absorb water from saturated solutions.
15. Soaps are prepared by the reaction of oils with NaOH. Glycerine is obtained as a by-product.
16. Detergents are used for their better cleansing properties than soaps.
17. Water is of much use in our daily life.
18. Carbon dioxide is prepared in the laboratory as follows : $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$
19. It is a colourless, odourless, soluble in water, heavier than air, turns blue litmus red and lime water milky.
20. It is also used in fire extinguishers.

Questions

1. List the characteristics of acids.
2. Name three examples of acids.
3. What are the formulae for Carbonic, Nitric, Sulphuric and Hydrochloric acids ?
4. Name three bases.
5. What are the general characteristics of bases ?
6. What are the reactants and products in a neutralization ?
7. How are the properties of acids and bases changed in a neutralization ?
8. What is a chemical indicator ? Name two chemical indicators.
9. What problems are caused by hard water ?
10. What three mineral elements make water hard ?
11. (*a*) What are acidic oxides? Give two examples.
    (*b*) What are basic oxides? Give two examples.
    (*c*) What are amphoteric oxides ? Give two examples.
12. If you are given three test tubes containing an acid, a base and water respectively, how will you determine the content of each one of them ?
13. Explain with examples
    (*a*) Efflorescence, (*b*) Deliquescence.
14. Explain with the help of equations how the following bases are formed :
    (*a*) Aluminium Hydroxide, (*b*) Potassium Hydroxide,
    (*c*) Calcium Hydroxide, (*d*) Sodium Hydroxide.

15. Explain with the help of equations how the following salts are formed :
    (*a*) Copper sulphate, (*b*) Sodium chloride,
    (*c*) Calcium nitrate, (*d*) Calcium carbonate.

16. Why is distilled water used in research laboratories ?

17. Write the equations for the reactions by which the following oxides can be obtained :
    (*i*) Sulphur dioxide (*ii*) Magnesium oxide
    (*iii*) Calcium oxide (*iv*) Carbon dioxide.

18. What indicators do you use to test for the following ?
    (*i*) An acid (*ii*) A base.

19. Fill in the blanks:
    What change of colour would you observe when the following indicators are added to the substances listed below :

	Methyl Orange	*Litmus*	*Phenolphthalein*
(*a*) Dil. H_2SO_4.	....	....	....
(*b*) NaOH soln.	....	....	....
(*c*) NaCl soln.	....	....	....
(*d*) Water.	....	....	....

20. Give a neat diagram to show the preparation of CO_2 gas in the laboratory.

Activity

1. Test juices of different fruits for acidity and alkalinity.
2. Listing acids, bases and salts and their uses in industry.
3. Listing uses of common salt in domestic spheres.

□□

CHAPTER 4

HEAT AND ITS MEASUREMENT

4.1 Introduction

This chapter is about heat. We will look at some of the things heat can do, and see how we make use of heat in our everyday lives.

We will ask the question 'What is heat'? and try to find an answer from the evidence of experiments done in the laboratory and at home.

You will find suggestions from experiments ; try these out if you can. They will all work and they will help you to understand the properties of heat.

You will find many questions in this chapter to stimulate you into thinking about heat. They will usually be easy, but if you have any difficulty try discussing them at home, or ask your teacher what he/she thinks.

4.2 Is Heat Energy ?

Already in your science course in Class VI you would have looked at different forms energy and seen how these can be converted from one form to another.

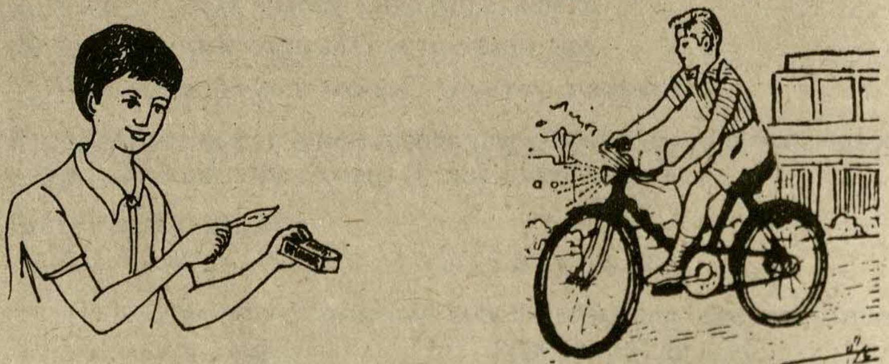
A person with plenty of energy can do lots of work. This is what all the forms of energy have in common. They can do work for us.

What are the changes that take place when you burn a match, light a lamp with a bicycle dynamo ; hammer a piece of lead for two or three minutes ; rub your hands together vigorously or twist a pointed stick very quickly in a piece of wood ?

Notice that each time something was warmer at the end of the change than when it started. We say that it has gained some *heat* or *thermal energy* and lost some other kind of energy.

The final resting place of most forms of energy is heat. This suggests that heat is probably a form of energy. The real test, however, is whether heat can do work such as making something move.

Here is just one example of heat doing work. The Ariane 3 rocket has put 1200 kg INSAT - 1C satellite into orbit. The heat from the burning fuel causes violent expansion of gases produced and gives the rocket its thrust. You will find other examples of heat energy doing work in everyday life, especially heat engines *i.e.*, steam engine ; car engine etc.



(A) (B)

Fig. 4.1 Heat is a form of energy.

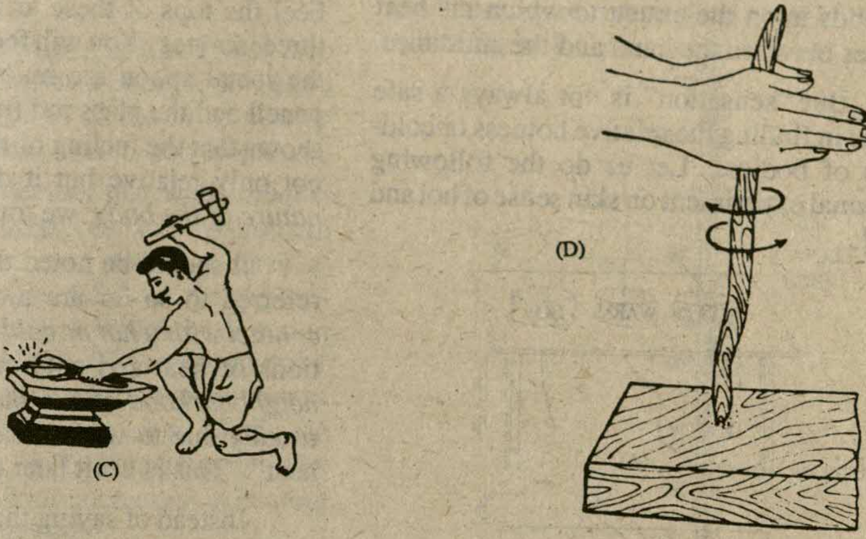
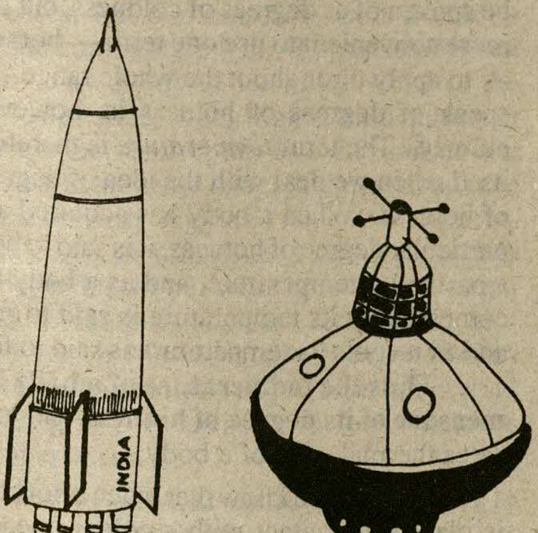


Fig. 4.1 Heat is a form of energy.

When water is boiled in a kettle with a loose lid, the steam forces its way out by pushing up the lid, which therefore moves up and down. Thus heat has caused motion. You can think of many more ways in which heat energy can cause motion.

Thus we conclude that heat is a form of energy.



(A) INDIAN ROCKET

(B) ARYABHATTA SATELLITE

Fig 4.2

4.3 Temperature as a Degree of Hotness
(Idea of "Hot" and "Cold" Bodies)

We generally distinguish in everyday life between "hot" and "cold" bodies by the sense of touch, that is, we know, by touching them, that one body is "hotter" or "colder" than another, and that the same body may become "hotter" or "colder".

When we touch a substance hotter than the hand we experience the "sensation" of heat, and we say that heat passes from the substances to the hand. In the same way when we touch a substance colder than the hand we get the sensation of cold, and we say that heat passes from the hand to the substance. In each case the amount of sensation depends upon the extent to which the heat passes between the hand and the substance.

But "sensation" is not always a safe guide in finding the relative hotness or coldness of bodies. Let us do the following personal experiment on skin sense of hot and cold.

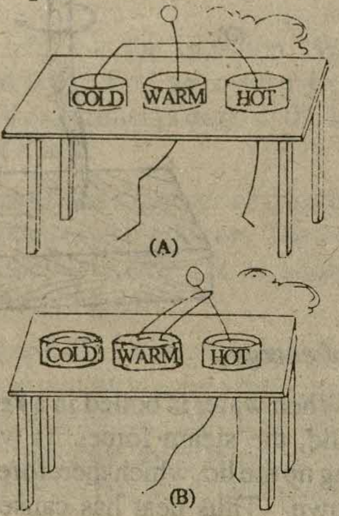


Fig. 4.3

Take three bowls. Fill the first one with water which is as hot as you can stand with your bare hands. In the second bowl mix hot water with cold water. This is lukewarm water. Put cold water from the tap into the third bowl. Place the bowls on a table as shown in Fig. 4.3. Hold your right-hand in the hot water and the left-hand in the cold water, for three minutes or more. You will find that your right-hand feels hot and your left-hand feels cold. After three minutes move both your hands into the lukewarm water. What do you feel ? Your left-hand feels warm and your right-hand feels cold. But both hands are in the same bowl of water; you cannot really tell if a thing is hot or cold by feeling it. *This shows that the feeling of hot and cold is relative and depends upon the previous state of the hand or other organ of touch.*

Fill a can with hot water. Put into it a pencil, a nail, a glass rod and a metal spoon. Feel the tops of these articles after two or three minutes. You will feel that the nail and the metal spoon are much hotter than the pencil and the glass rod (non-metals). This shows that the feeling of the hot and cold is not only relative but it depends upon the *nature of the body* we touch.

It should be noted that the sensations referred to so far are those due to *actual contact with a hot or cold body*. The sensations of heat and cold experienced *in the neighbourhood of hot and cold bodies* are usually due to what is called "radiation of heat". This is dealt later on in Chapter 6.

Instead of saying that a body becomes hotter or colder we may say that a body acquires higher or lower *degrees of hotness*. Degrees of hotness below a certain standard, say that of the human body, might perhaps be spoken of as degrees of coldness, but it is more convenient to use one term — hotness — to apply throughout the whole range. To speak of degrees of hotness is, however, clumsy. The term *temperature* is therefore used when we deal with the idea of degrees of hotness. When a body has acquired any particular degree of hotness, it is said to be at a particular temperature, and as a body becomes hotter its temperature is said to rise, and as it cools its temperature is said to fall.

Thus the temperature of a body is a measure of its degree of hotness and indicates thermal state of a body.

Further, we know that when a hot body is placed in contact with a colder one, the hotter body becomes colder and the colder body becomes hotter. Heat has, of course, passed from the hot body to the cold body or, as we usually put it, heat has passed from the body at the higher temperature to the body at the lower temperature. As a matter of fact this flow of heat goes on until the two bodies come to the same temperature. If two bodies are at the same temperature no heat passes from one to the other when they are placed in contact.

Hence temperature of a body may also be defined as its (thermal) state or condition which determines the direction of flow of heat between a body and its surroundings.

Always remember that whilst ***heat*** is the agent which produces the sensations of hotness, coldness, etc., and is a *form of energy, temperature* refers to the *thermal state* or *condition* which settles the direction in which heat will flow. The temperature of a body certainly depends on the amount of heat— the more heat we give to a body the higher, as a rule, is its temperature. The temperature of a body increases on heating and decreases on cooling.

4.4 Temperature Measuring Device — Thermometer :

We can use our skin to make *rough* guesses, but our sense of hot and cold is limited and unreliable. Our sense of touch can be used only to determine which of the two substances is at a higher temperature. It cannot be used if the two substances are almost at the same temperature, nor can it be used for very high and very low temperatures. We, therefore, need a device which is independent of our sense of touch and which will measure the hotness or coldness of a body. Such a device is called a *thermometer.* A thermometer tells us just how hot or cold a thing is ; it can be used for comparing temperatures.

A thermometer is an instrument used to measure temperature.

There are different types of thermometers, but the most common type has a liquid (usually mercury or coloured alcohol) in a small bulb at the end of a long, narrow tube on which some marks are scratched (Fig. 4.4). Some of the liquid is in the tube. As the temperature rises, more of the liquid from the bulb expands along the tube. The number written against the mark on the scale to which the liquid rises indicates the temperature of the bulb.

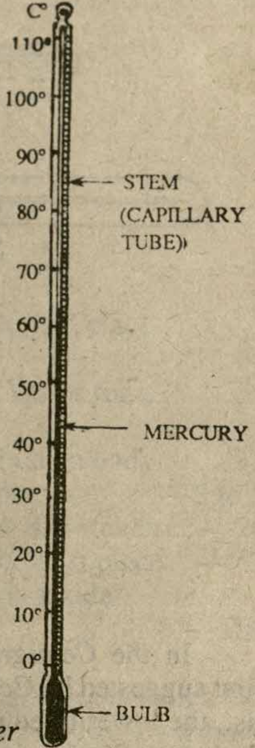


Fig. 4.4
Mercury Thermometer

To get the standard scale of *markings* or *graduations* on a thermometer two *fixed points* must first be found. These points are temperatures which are easily obtained (See Art., Chapter 5). The *lower fixed point* is the temperature of melting ice. The *upper fixed point* is the temperature of steam from boiling water.

Having marked on the tube the upper and lower fixed points of the thermometer, we are now ready to divide the space between these two points into a number of equal divisions. This can be done in a number of ways, but there are two particular scales of division in common use : one, called *Centigrade* or *Celsius,* has one hundred divisions or degrees between the two fixed points ; while the other, called the *Fahrenheit,* has one hundred and eighty divisions (Fig. 4.5)

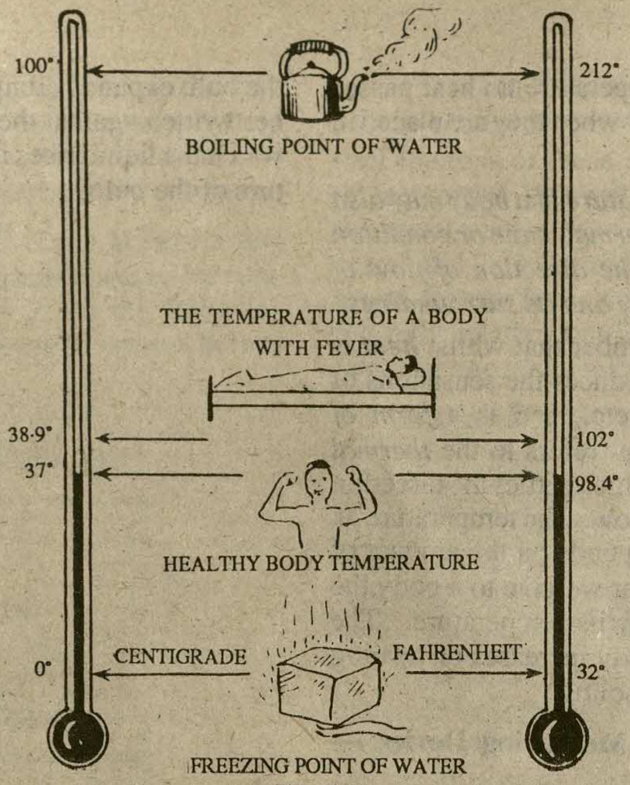


Fig 4.5

In the Centigrade scale, which was first suggested by Celsius, a Swedish scientist, the lower fixed point is called 0°C and the upper fixed point 100°C and the space between them is divided into 100 degrees. Today most people all over the world, including scientists, use the Centigrade scale and is very convenient. In the Fahrenheit scale, which was first suggested by Fahrenheit, a German merchant, the lower fixed point is called 32°F and the upper fixed point 212°F and the space between them is divided into 180 degrees. The coldest thing which Fahrenheit knew in his days was a mixture of salt and ice, and he called the temperature of this mixture 0°F, while his upper fixed point was the temperature of the human body, which was then thought to be 96°F. It has since been found that the temperature of a normal human body is 98.4°F (or 37°C). The Fahrenheit scale is used chiefly in Great Britain and America.

In order to convert the temperature on the Celsius scale to the Fahrenheit-scale, we use the following relation :

$$\frac{C}{100} = \frac{F-32}{180}$$

where C is the reading on the Celsius scale and F is the reading on the Fahrenheit scale.

Absolute or Kelvin Scale

This is the same as Celsius scale with the difference that its zero is at −273°C. Thus 0°C corresponds to 273 K where K stands for Kelvin. The upper fixed point (100°C) is 373K. The interval between the lower fixed point and the upper fixed point is divided into 100 equal divisions. Zero degree Kelvin (K) is —273°C which is the lowest temperature that can never be achieved.

A special type of thermometer is used to take the temperature of a human body when he goes to see the doctor. It is called a *clinical thermometer* (Fig. 4.6).

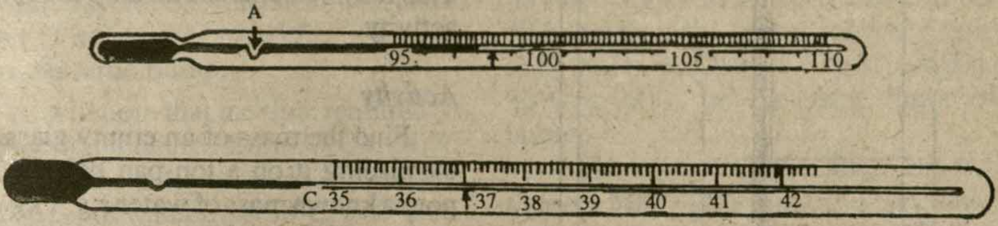


Fig. 4.6

This is a small type of (Fahrenheit or Celsius) thermometer about 10 cm long. A healthy person has a temperature of 98.4°F (or 37°C). Any great deviation from this indicates illness. 105°F is regarded as very dangerous.

To obtain the temperature of a patient the nurse usually places the thermometer under the tongue or in the armpit. This thermometer has a short, very thin capillary tube with a narrow portion (or constriction) at A. In expanding, the mercury flows out of the bulb past the narrow portion, but when the thermometer is taken out of the patient's mouth or armpit, the mercury does not flow back past the constriction. Thus the temperature can easily be recorded and read. To bring the mercury back into the bulb, the thermometer is shaken vigorously and the mercury is thus forced back through the constriction. This thermometer is graduated from 95° to 110°F (or 35° to 42°C).

Table Showing Some Common Temperatures

(in degrees C)

Temperature at the surface of the sun	6000
Temperature of the bright side of the moon	100
Freshly prepared tea	80
Temperature of the hotted place on earth	51
Temperature of Hot Water for a usual bath	45
Temperature of the human body	37
Temperature of ice cream	—5 to 5
Temperature of ice & salt mixture	—20
Temperature of the coldest place	—42
Temperature of the dark side of the moon	—180

4.5 Different factors upon which the amount of heat gained or lost by a body depends :

We are already familiar with the idea that heat is a form of energy. Temperature is a measure of the heat energy level. The heat required by a body increases with its quantity provided the rise in temperature remains the same. This may be demonstrated by the following experiment.

Activity:

Find the mass of an empty glass beaker by placing it on a top-pan balance. Then pour a known mass of water *e.g.*,500 g into the beaker. Place a stirrer and a thermometer in the water, put the glass beaker over the burner flame as shown in Fig. 4.7 and start your stopwatch. Keep on stirring the water as it is being heated. Stop the watch when the

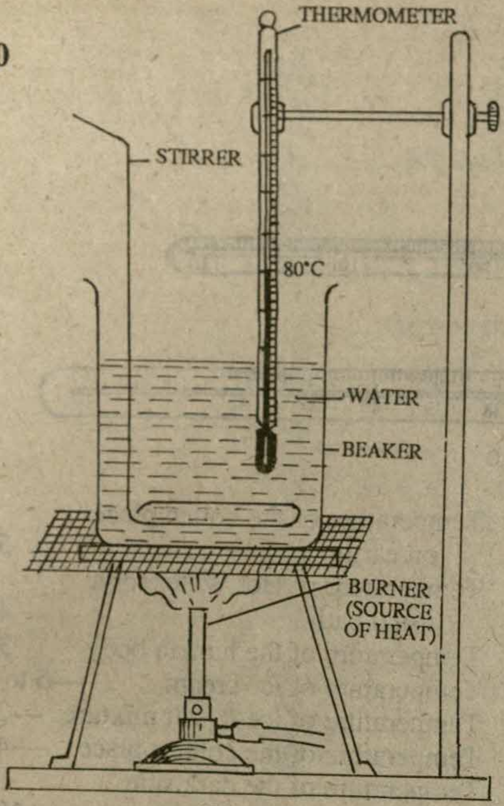


Fig. 4.7

water gets heated upto a temperature say 80°C. Note the time it takes for water to get heated upto 80°C.

Pour the water out and repeat the experiment with double the quantity of water *e.g.*,1000 g or 1 kg from the same tap or source. Note the time it takes for water (1 kg) to get heated upto 80°C.

You will note that the time required to get 1 kg of water heated upto 80°C is more than the time required to get 500 g of water heated upto 80°C *on the same flame of the burner*. More time means more heat gained by water. In other words, the heat required by 1 kg of water to raise its temperature upto 80°C is more than the heat required by 500 g of water to raise its temperature upto 80°C.

Thus we can say that *the heat required by a substance to raise its temperature through a given range increases with its quantity.*

It is also a common experience tha more heat is required for higher rise in temperature of a known quantity of a substance. This may be demonstrated by the following activity.

Activity

Find the mass of an empty glass beaker by placing it on a top-pan balance. Then pour a known mass of water *e.g.*,1 kg into the beaker. Place a stirrer and a thermometer in the water.

Note the temperature of water at room temperature say 30°C. Now put the glass beaker over the burner flame as shown in Fig. 4.8 and start your stop-watch. Keep on stirring the water as it is being heated. Stop the watch when water gets heated upto a temperature say 60°C. Note the time it takes for water to get heated upto 60°C.

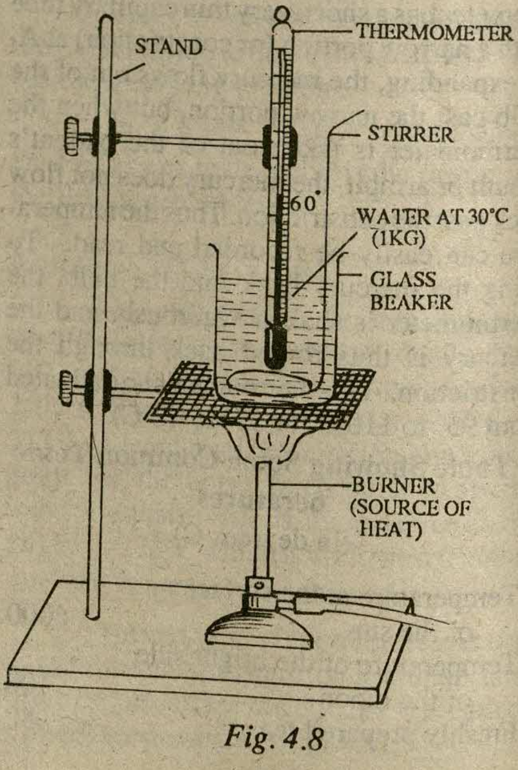


Fig. 4.8

Pour the water out and repeat the experiment taking the same quantity of water (*i.e.*, 1 kg) from the same source at the room temperature say 30°C. Note the time it takes for water (1 kg) to get heated from 30°C to 90°C on the same flame.

You will note that the time required to get 1 kg of water heated from 30°C to 90°C is more than the time required to heat the same quantity of water from 30°C to 60°C on the same flame of the burner. More time means more heat gained by water.

Thus we can infer from this activity that *for higher rise in temperature of a known quantity of a substance, more heat is required.*

When equal masses of different substances are heated to the same range of temperature, they do not require the same quantity of heat energy. This may be demonstrated by the following activity :

Activity :

Find the mass of an empty glass beaker by placing it on a top-pan balance. Then pour a known quantity of water *e.g.*,1 kg into the beaker. Place a stirrer and a thermometer in the water and note down the temperature of water at room temperature say 30°C. Now put the glass beaker over the burner flame as shown in Fig. 4.8 and start your stop-watch. Stir water continually. When the temperature of water rises upto 60°C, stop the stop-watch. Note the time it takes for 1 kg of water to get heated from 30°C to 60°C.

Pour the water out and repeat the experiment with an *equal mass of another liquid e.g.*,paraffin. After heating it through the same range of temperature *i.e.*,from 30°C to 60°C on the same flame of the burner, you will note that the time required by the paraffin is different. If the same mass of a third liquid is used, a different time interval will be obtained. Different time means different amount of heat is gained. In other words, the amount of heat required to raise the temperature of 1 kg of water from 30°C to 60°C is different from the amount of heat required to raise the temperature of 1 kg of paraffin from 30°C to 60°C on the same flame of the burner.

Thus we can infer from this activity *that the heat required to raise the temperature of the same quantity of different substances through same range is not the same.*

From the above mentioned activities we have learnt that whenever a substance is heated, its temperature rises and hence the substance gains heat. Had we cooled the substance, its temperature would have fallen and hence it would have lost heat. In other words whenever the temperature of a substance falls, it loses heat. We can, therefore, conclude that ***the amount of heat*** gained or lost by a substance depends upon the following factors :

(*i*) mass of the substance,
(*ii*) rise or fall in temperature (or change in temperature) of the substance, and
(*iii*) nature of the material of the substance.

4.6 Units of Heat

We are already familiar in a general way with the idea of *amount or quantity of heat.* We know from our everyday experience that a greater quantity of heat is required to heat a large mass of water from 0°C to 100°C than to heat a small mass of water through the same range of temperature. The meaning of the term " quantity of heat" used in this general way is well understood but it is necessary to decide exactly how quantity of heat is to be measured or in what specific units it is to be expressed.

The unit of heat used by scientists is based on C.G.S. (centimetre-gramme-second) system of units : it is called the *calorie*, and is defined as follows :

A calorie is the amount of heat required to raise the temperature of 1 gram of water through 1°C.

This means that when 1 calorie of heat is supplied to 1 gram of water, its temperature will rise by 1° C.

When a larger heat unit is desirable the *kilo-calorie* is used. It is equal to 1000 calories and *is the heat required to raise the temperature of a kilo-gramme of water through 1°C.*

1 kilo-calorie = 1000 calories

Since heat is a form of energy hence these days internationally heat is measured in ***joule.*** It is abbreviated as J.

One calorie is related to joule as follows :

1 calorie = 4.184 joules ≈ 4.2 J

1 kilo-calorie = 4200 joules

4.7 Specific Heat of a substance

If we take 1 kg of pure water and heat it for sometime say 15 minutes, its temperature will rise. Similarly, if we take 1 kg of copper which is much denser than water and heat it by the same power source for the same interval of time *i.e.*,15 minutes, the temperature rise will be found to be about ten times that of the water. Paraffin, which is less dense than water, has a higher temperature rise when an equal quantity of heat is given to 1 kg of it for the same interval of time. It would appear that when equal quantities of heat energy are given to equal masses of different substances, the relative density has nothing to do with the rise in temperature. The property which is responsible for the different temperature rises is known as the *specific heat capacity* of the substance.

Specific heat of a substance is defined as the quantity of heat energy which will raise the temperature of unit mass (1 kg) o a substance by 1 °C.

It is usually denoted by the letter c. It unit is J/kg/°C or joule per kilogram degre centigrade. It may also be expressed as kilo-calorie per kilogram degree centigrade or K cal/kg/°C.

If unit of mass is taken as gram, the specific heat is expressed as calories pe gram degree centigrade or cal/g/°C.

The *heat capacity of a substance* is the amount of heat needed to raise the temperature of a substance by 1°C.

The unit of heat capacity is *joules pe ℃.* Since oil requires less amount of heat to raise its temperature by 1°C than same amoun of water the heat capacity of oil is less than that of water. *In fact water has the highest heat capacity compared to most other substances.*

Table 4.1

Specific heat capacities of various substances in J/kg/°C.

Aluminium	900
Zinc	376
Brass	380
Copper	400
Iron	450
Lead	130
Alcohol	2404
Air	1003
Vegetable oil	1965
Mercury	140
Marble	900
Water	4200
Ice	2100
Paraffin	2270
Gold	170
Silver	230
Kerosene	2112

It follows from the definition of specific heat capacity that c joule of heat energy will raise the temperature of 1 kg of a substance by 1°C. Thus the quantity of heat that raises the temperature of *m* kg by 1°C is mc joule, and the quantity of heat that raises this mass through T°C is mcT joules. The general equation is given by

Q = mcT where Q is change in heat energy of the mass m and T is the change in temperature.

Heat energy may be absorbed or emitted from the substance. If it is absorbed there will be a rise in temperature, and if it is emitted, there will be a fall in temperature.

Quantity of heat gained or lost	=	Mass of the substance	×	Specific heat of the substance	×	Rise or fall in temperature
Q	=	m	×	c	×	T

$$\boxed{Q = mcT}$$

Example :

How much heat energy is required to raise 2 kg of water from 20°C to its boiling point at 100°C ? Specific heat of water is 4200 J/kg/°C.

Solution :

$$m = 2 \text{ kg}$$
$$c = 4200 \text{ J/kg/°C}$$
$$T = 100-20 = 80\text{°C}$$

$$\begin{aligned} \text{Heat energy required} &= Q \\ &= mcT \\ &= 2 \text{ kg} \times 4200 \frac{\text{J}}{\text{Kg°C}} \times 80\text{°C} \\ &= 2 \times 4200 \times 80 \text{ J} \\ &= 672000 \text{ J} \end{aligned}$$

Sometimes it is important that we know how much heat a burner supplies to a vessel placed on it *per unit time*. This knowledge will enable us to supply the desired amount of heat to any substance.

Suppose in the above mentioned example the amount of heat 672000 J is received by the water in 20 minutes. This means this heat was supplied by the burner in 20 minutes.

∴ The heat supplied by the burner in *one minute* = $\frac{672000}{20}$ joules = 33600 joules

Thus if we have measured the initial temperature T_1 and the final temperature T_2 we can find the number of joules supplied by the burner per minute.

4.8 Flow of heat energy :

Earlier it was stated that temperature is a measure of the level of the heat energy. Water always flows from a higher to a lower level irrespective of the quantity of water at each level. The same is true of heat energy. Heat energy always flows from a higher to a lower level *i.e.*, from a higher temperature to a lower temperature, irrespective of the quantity of heat energy at each level. When a red hot spark falls into a pail of water, heat energy flows from the spark to the water, although the water contains far more heat energy than the spark. The flow of heat energy continues until the two temperatures are equal.

4.9 Substance may change their state on heating or cooling (Change of State) :

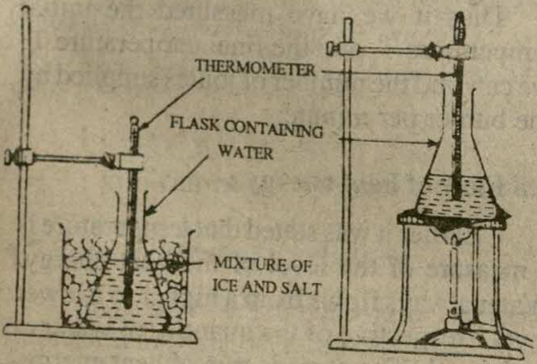
You have learnt in Class VI that matter exists in three states, namely, solid, liquid and gas. You have also learnt that matter can be changed from one state into another. The following experiments illustrate what happens as one state is changed into another.

Experiment :

To find out what happens during a change of state.

Apparatus :

Two conical flasks containing water, a large vessel containing a mixture of ice and common salt, thermometer, bunsen burner, tripod stand.



(a) (b)

Fig. 4.9

Procedure:

(*a*) Place the first conical flask inside the vessel containing the mixture of ice and salt and erect a thermometer vertically in the flask [Fig. 4.9 (a)]. Take the temperature at one minute intervals until the temperature reaches about–3°C. Draw a graph of *temperature* along the Y-axis against *time* along the X-axis.

Record what you notice about the water.

(*b*) Weigh the second flask with some water in it. Place it on the bunsen flame [Fig. 4.9 (b)] and start taking the temperatures at intervals of one minute until the water has boiled for five minutes. Draw a graph in the same way as in (a) above.

(*c*) Now cool the flask and weigh it again with the water inside. Record your readings and your observations in the following manner :

Time (min)	(a) Temperature (°C) of water being cooled	(b) Temperature (°C) of water being heated

Weight of beaker + water before heating = g

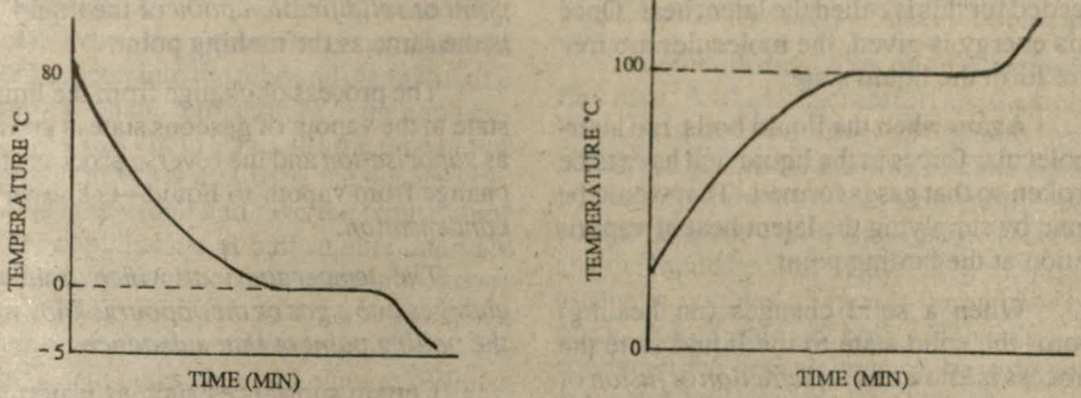
Weight of beaker + water after heating = g

Loss in weight of water = g

You will observe that in (a) :

(i) as the water is cooled, the temperature goes down along a smooth curve to 0°C, where it remains the same for a long time before it starts going below 0°C [see Fig. 4.10 (a)] ;

(*ii*) at the end of the experiment the water has turned to ice.



(*a*) (*b*)

Fig. 4.10

Notice that in (b) :

(*i*) the temperature rises uniformly along a smooth curve until it gets to around 100°C, where it remains without rising any further [see Fig. 4.10 (b)] ;

(*ii*) the weight of the water at the end of the experiment is less than it was before heating started.

Explanation:

(*a*) The temperature of the water remains at 0°C during the period that the water is changing from water into ice and does not go below 0°C until all the water has frozen. During the process heat is being lost from the water, but the thermometer does not show this. Such heat is *invisible*, and is known as ***latent heat of fusion*** of ice. When any liquid changes from liquid to solid it is said to be losing its latent heat of fusion and there is no change of temperature during the period of change.

(*b*) The temperature of the water remains at about 100°C during the period that the water is changing from water into steam and does not rise beyond it until all the water has changed into steam. Heat is being given to the water during the process, but the temperature does not show it. This again is *invisible* heat and is called **latent heat of Vaporisation of water.** When any liquid changes from liquid into gas it is said to be absorbing latent heat of vaporisation and there is no change of temperature during the process.

(*c*) In the second experiment some of the water has changed into steam, hence the weight of the water after heating is less than it was before heating.

The reason behind the latent heat of absorption is as follows :

Matter exists in three states and consists of molecules. Molecules attract one another with weak forces of attraction called *intermolecular force.* This force holds them together in a *condensed* state as a solid or a liquid. *The heat supplied to ice at 0 °C is used* *up to weaken this intermolecular force but not to increase the temperature.* The energy needed for this is called the latent heat. Once this energy is given, the molecules are free and form the liquid state.

Again when the liquid boils, the intermolecular forces in the liquid will have to be broken so that gas is formed. That would be done by supplying the latent heat of vaporisation at the boiling point.

When a solid changes (on heating) from the solid state to the liquid state the process is known as *liquefaction* or *fusion* or *melting*. When a liquid changes (by the withdrawal of heat) from the liquid state to the solid state, the process is known as **solidification** or **freezing** or **crystallization.**

The fixed temperature (different for different substances) at which a solid changes into a liquid is known as the melting point of the substance.

The fixed temperature (different for different substances) at which a liquid changes into a solid is called the freezing point or *solidification point* of the liquid. It is the same as the melting point.

The process of change from the liquid state to the vapour of gaseous state is known as *vaporisation* and the reverse process—the change from vapour to liquid—is known as *condensation.*

The temperature at which a liquid changes into a gas or the vapour is known as the boiling point of that substance.

Certain substances such as water and several salts have sharp boiling and melting points, and they are even identified by these values, while others, such as candle wax, do not have such a definite melting point.

Activity :

To determine the melting point of some solid say naphthalene by plotting its cooling curve.

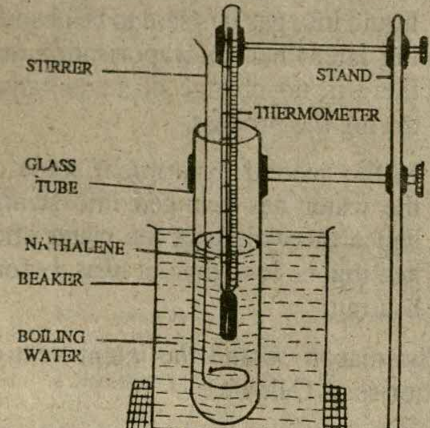


Fig. 4.11

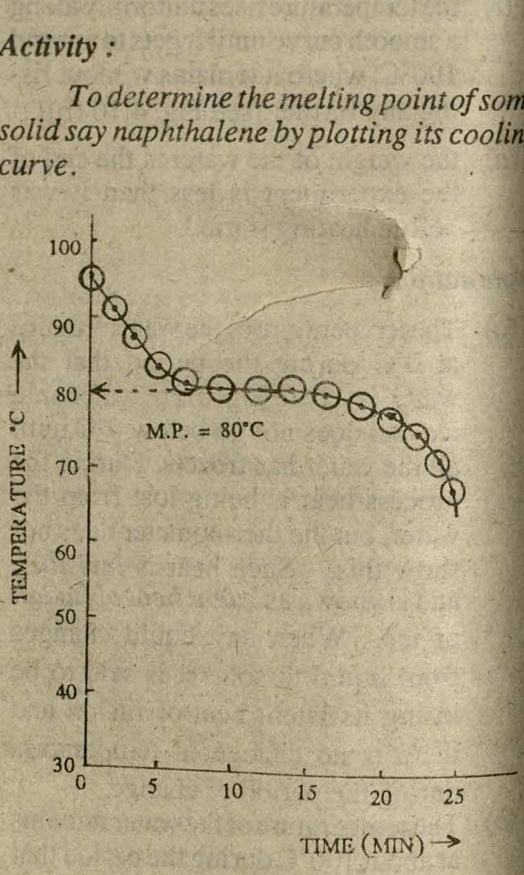


Fig. 4.12
Cooling Curve for Naphthalene

Clamp a glass tube containing naphthalene into a stand and then lower the tube into a beaker containing boiling water (Fig. 4.11). When the naphthalene melts insert a thermometer into the tube and clamp it to the stand. Then the temperature of the naphthalene reaches about 95°C, lift the tube out of the boiling water and wipe the outside dry. Start a stop-clock and take the temperature of the naphthalene at half minute intervals until the readings become more or less constant. Then continue to take temperature readings at one minute intervals. The whole experiment takes about 40 minutes. Whilst the liquid is cooling it should be shielded from stray draughts and stirred as much as possible to prevent irregular solidification. At the end of the experiment reheat the naphthalene before trying to remove the thermometer, otherwise you may leave the thermometer bulb in the naphthalene.

Plot a graph of temperature against time as shown in Fig. 4.12 and extrapolate the horizontal part of the graph to the temperature axis to determine the melting point of naphthalene. The melting point is seen to be 80°C. This method is the most reliable one.

Table of Melting Points

Sodium	98°C	Iron	1535°C
Sulphur	115°C	Phosphorus	44°C
Naphthalene	80°C	Ice	0°C
White Wax	68°C	Perspex	75°C
Paraffin Wax	52°C	Nylon	200°C
Copper	1082°C	Lead	327°C
		Zinc	410°C

Activity :

To determine the boiling point of some liquid say water.

Place some water in a conical flask fitted with a thermometer as shown in Fig. 4.9(b). Arrange the thermometer so that the bulb is well immersed in the water. Heat the flask gently and observe the behaviour of the liquid and the readings of the thermometer.

As the heating goes on, the temperature rises. As the temperature rises, the small bubbles of air are formed and escape from numerous points on the walls of the flask. Ultimately, however, the temperature becomes stationary at a fixed point (100°C) and the liquid becomes agitated by the rapid escape of bubbles of vapour throughout its mass, and is said to boil. If heating is continued the boiling goes on steadily and the water boils away ; that is, changes to water vapour, but the temperautre remains practically constant (100°C).

If the thermometer is now raised so that the bulb is not in the water but in the *steam*, it will be found that the temperature still remains constant. *This constant temperature is the boiling point of water.*

Table of Boiling Points of Common Substances : (at Normal Atmospheric Pressure)

Mercury	357°C
Turpentine oil	156°C
Water	100°C
Alcohol	78°C
Ether	35°C
Iron	2750°C
Copper	2310°C
Zinc	907°C

Can a liquid turn into a gas without boiling? (*Evaporation*)

If you weigh a beaker of water and leave it on the table overnight, then re–weigh it the following morning, you will notice a loss in weight showing that some of the water has escaped into the air during the night. *This change of water into vapour without the application of heat to it is known* *without the application of heat to it is known as evaporation.* This is well illustrated when you leave damp clothes spread out in the air to dry. In the same way the waters of the oceans, lakes and rivers evaporate slowly *at all temperatures*.

The rate of evaporation depends upon several factors :

1. *The area of the surface exposed :* A wet piece of cloth would dry much more quickly if spread out than if left folded. A large surface area aids evaporation.
2. *The temperature of the liquid :* A wet piece of cloth dries much more quickly on a hot, sunny day than on a cold, wet one. Heating aids evaporation.
3. *The wind :* A wet piece of cloth would dry much more quickly on a windy day than on a calm day. The wind helps to remove the vapour as it is formed.
4. *The dryness of the atmosphere :* When the atmosphere is laden with moisture, the rate of evaporation decreases ; but when it is dry the rate of evaporation is quickened. Hence wet clothes dry more quickly in dry air than in damp air.
5. *The nature of the liquid :* If you place equal quantities of ether, alcohol, petrol, water and palm oil in identical vessels exposing equal areas of their surfaces to the air you will find that they will evaporate at different rates, the ether having the highest rate of evaporation. Thus different liquids evaporate at different rates.

Evaporation produces Cooling :

Try the following activity :

Activity :

To show that evaporation causes cooling.

Requirements :

A beaker containing some ether; match box ; glass tube.

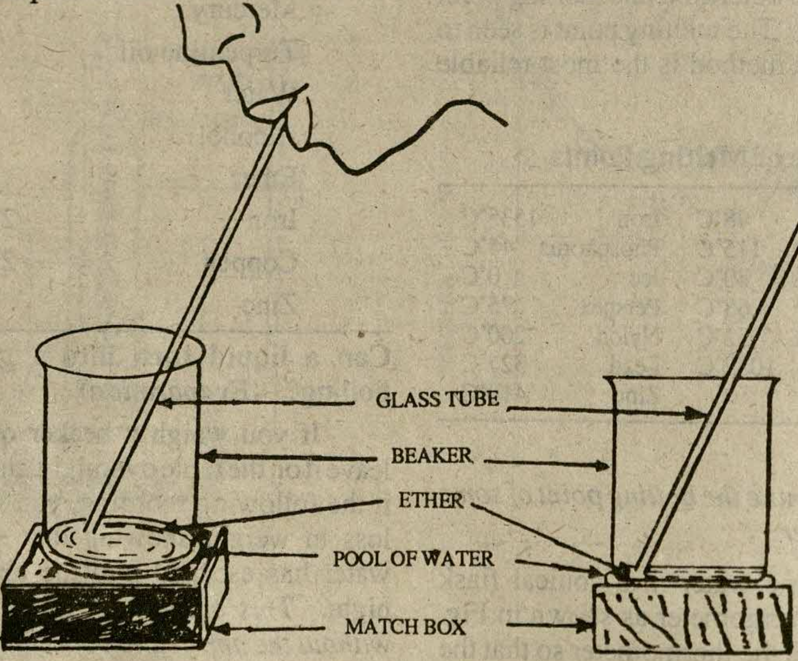


Fig. 4.13
Evaporation causes cooling

Procedure :

Make a small pool of water on a match-box. Put on it a beaker containing some ether. Using a glass tube, blow some air through the ether (Fig. 4.13). Continue to blow until all the ether has evaporated. Touch the sides of the beaker. Also try to lift up the beaker. What do you notice ?

You will observe that the sides of the beaker will grow cold and wet within a few seconds. You will also see that when you try to lift the beaker the match box comes up with it.

Explanation :

As the air is blown through the ether, the ether evaporates very quickly. In evaporating (*i.e.*, changing from liquid into vapour) it absorbs heat (*i.e.*,latent heat of vaporisation) from the surrounding air and from the water underneath the beaker. Thus, the water vapour in the air condenses on the side of the beaker and the water underneath it gets so cold that it freezes (*i.e.*,it turns into ice). This makes the beaker stick on to the match-box and it becomes difficult to separate them. Thus, evaporation causes cooling.

There are numerous *practical applications* in everyday life based on the phenomenon that evaporation causes cooling. Some are mentioned below :

(*i*) Water in an earthen pot or *surahi* becomes cooler because an earthen pot has a large number of extremely small pores. Water comes out through them and evaporates from the surfaces, cooling the whole system. The heat required for evaporation is taken from the water in the earthen pot. Cooling produced this way also helps to keep the milk in a milk bottle fresh when the milk bottle is placed in the water and the unglazed earthenware jar is inverted over it. This device is useful when no refrigerator is available *e.g.*,when camping. If no earthenware jar is available, a wet muslin cloth can be used instead.

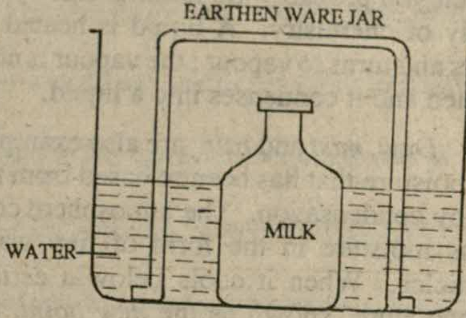


Fig. 4.14

(*ii*) During summer, we perspire and evaporation of perspiration helps to cool our bodies.

(*iii*) Evaporation of water from the trees keeps them cool during summer months.

Condensation :

When air that contains water vapour or moisture is cooled to a cetain temperature some of the moisture will come out as droplets of water as you saw in the last activity. You have probably seen water vapour form droplets on a glass of iced water or on a bottle of limca which has been in a refrigerator. If you breathe with your mouth on a piece of mirror you will also get moisture forming on the mirror. These examples show that when air containing moisture is cooled some of the moisture is released and deposited.

When the moisture which we cannot see in air becomes droplets of water which we can see, the process is called *condensa-*

tion and the water vapour is said to *condense*. Condensation is the opposite of evaporation. When a liquid evaporates, it turns into a gas ; when a gas condenses, it changes to a liquid.

A good example of the use of evaporation and condensation is distillation, with which you probably are familiar from your study of chemistry. A liquid is heated, it boils and turns to vapour ; the vapour is now cooled and it condenses into a liquid.

Dew, mist and *rain* are also examples of moisture that has been released from the air by condensation. The atmosphere contains moisture in the form of tiny water particles. When it cools below a certain temperature, known as the *dew point*, the water particles collect together and form dew, mist or rain. Dew and mist are formed close to the earth's surface. Rain comes from the suspended clouds, which are really suspended water particles, and which on collecting together become sufficiently heavy to fall down as rain.

Difference between evaporation and boiling :

1. Evaporation takes place from the surface of the liquid whereas boiling is due to vapour formation inside the whole liquid.
2. Evaporation takes place at all temperatures whereas boiling takes place at a fixed temperature under a definite pressure.
3. Evaporation is a slow process whereas boiling is a quick process.

Summary

1. Heat is a form of energy which is being taken up by a material, being given up by a material, or being transferred from one material to another.
2. A body may be hot or cold in comparison with other bodies. The sensation of hotness or coldness is relative.
3. Degree of hotness or coldness in a body is called temperature. The device used for measuring temperature is called thermometer.
4. The temperature of a substance increases on heating and decreases on cooling.
5. The quantity of heat gained or lost by a body depends upon different factors.
   - (*i*) The quantity of heat gained or lost by a known quantity of a substance depends upon the rise or fall in its temperature.
   - (*ii*) The quantity of heat gained or lost by a substance to raise or lower its temperature through a given range depends upon the increase or decrease with its quantity.
   - (*iii*) The quantity of heat gained or lost to raise or lower the temperature of same quantity of two substances through the same range is not the same.
6. Calorie ; kilo-calorie and joule are the various units of heat.
7. Specific heat of a substance is the heat required to raise the temperature of 1 kg of a substance through 1°C. Its unit is joule/kg/°C.
8. The amount of heat gained or lost by a substance is given by

   Heat gained or lost = mass of the substance × specific heat of the substance × rise or fall in temperature.

9. Substances may change their state on heating or cooling. Solid substances melt on heating. Liquids form solids on cooling. Liquids change into gaseous state on heating. Gases change into liquids on cooling.

10. During any change of state the temperature remains the same until the whole substance has changed and latent heat is either absorbed or given out.

11. The phenomenon of change of state from the solid to the liquid is called *fusion* or *liquefaction* or *melting*.

12. The phenomenon of change of state from the liquid to the solid is called *solidification* or *freezing* or *crystallization*.

13. The temperature at which a solid changes into a liquid is known as the *melting point* of the substance. The temperature at which a liquid changes into a solid is called the *freezing point* or *solidification point* of the liquid.

14. Each solid substance has a definite melting point. The melting point and freezing point for a substance are same.

15. The phenomenon of change of state from the liquid to the gaseous or vaporous state is called *vaporization*.

16. The temperature at which a liquid changes into a gas, and vice versa, is called its *boiling point*. Each liquid substance has a definite boiling point.

17. Change of liquid into vapour without the application of heat to it is known as *evaporation*. It takes place at all temperatures and it always causes cooling.

18. Evaporation is aided by the wind, exposure of a wide surface area, a rise in temperature and the dryness of the atmosphere.

19. Condensation is the opposite of evaporation.

Questions

(A) Objective Type Questions :

1. Complete the following statements by filling the blanks with suitable words :

(*i*) Heat always flows from a body at a .... to a body at a..............

(*ii*) A thermometer measures ....

(*iii*) 37°C is the temperature of a ....

(*iv*) Whenever a substance undergoes a change of state it does so at a .... temperature.

(*v*) Heat is capable of doing work as in ....

(*vi*) The unit of heat as a form of energy is ....

(*vii*) The fixed temperature at which a solid changes into a liquid is known as the .... of the substance and the fixed temperature at which water changes into steam is known as the .... of water.

(*viii*) The unit of specific heat of a substance is ....

(*ix*) .... expresses the degree of hotness or coldness possessed by a body.

(*x*) Evaporation takes place at .... temperatures and it always causes ....

2. Write true (T) or false (F) against the following statements :
   (*i*) Heat is a form of energy and it can do work.
   (*ii*) Temperature of a body decreases on heating and increases on cooling.
   (*iii*) The boiling point of water is 98°C.
   (*iv*) The heat required by a body increases with its quantity provided the rise in temperature remains the same.
   (*v*) During any change of state the temperature does not remain the same until the whole substance has changed.
   (*vi*) Water gives out heat when it is changing to ice at 0°C.
   (*vii*) Ether evaporates only at 60°C.

3. Match the words given in Column *A* with those of Column *B* and write the complete sentences :

Column A	**Column B**
(*a*) Melting point of ice is	(*a*) its mass
(*b*) Joule or calorie is the unit of	(*b*) change of state from the liquid to the gaseous state
(*c*) Vaporization is the process of	(*c*) heat
(*d*) Heat lost or gained by a body depends upon	(*d*) 0°C
(*e*) A thermometer measures	(*e*) heat energy flows from a body at a higher temperature to a body at a lower temperature
(*f*) When two bodies at different temperatures are brought in contact with each other,	(*f*) the temperature of a body

4. Choose the appropriate answer :
   (*i*) Condensation is opposite of
   (*a*) boiling (*b*) evaporation (*c*) melting
   (*ii*) Kilo-calorie is the unit of
   (*a*) work (*b*) heat (*c*) mass (*d*) density
   (*iii*) The melting point of ice is 0°C. As it starts melting into water, its temperature during the change would be
   (*a*) 30°C (*b*) 0°C (*c*) 10°C (*d*) 20°C

(*iv*) The quantity of heat gained or lost by a body depends upon its

(*a*) mass alone (*b*) mass; specific heat and rise or fall in temperature (*c*) rise or fall in temperature alone (*d*) its density alone.

(*v*) Copper chips at 98°C are mixed with water in a beaker at 30°C. After continuously stirring the mixture for some time it is found that the mixture attains a common temperature. The common temperature of the mixture can be

(*a*) 25°C (*b*) 48°C (*c*) 108°C

(*vi*) The melting point of naphthalene is 80°C. Its freezing point is

(*a*) 60°C (*b*) 80°C (*c*) 110°C (*d*) 200°C.

(B) Very Short Answer Type Questions :

1. What is a kilo-calorie ?
2. What is a joule ?
3. What is calorie ?
4. What change of state is called fusion ?
5. What name is given to the temperature at which fusion occurs ?
6. What is temperature ?
7. What is a thermometer ?
8. Define 'heat'.
9. Define specific heat of a substance.
10. What is common or equilibrium temperature ?
11. What is evaporation?
12. What temperature change takes place during a change of state ?
13. Mention three factors that affect evaporation.
14. What is meant by boiling point ?
15. What is the unit of specific heat ?
16. What is the freezing point of water on the Fahrenheit scale ?
17. Name the process opposite of fusion.
18. What is wrong with the statement :
    'The oven is fitted with a thermometer to measure the heat'. Write it correctly.

(C) Short Answer Type and Essay Type Questions :

1. Distinguish between heat and temperature. Mention the unit of each.
2. What are the factors upon which the quantity of heat communicated to a substance (which does not melt or vaporise) depends ?
3. What is heat ? Give the units of specific heat in the C.G.S. system and SI system of units.
4. Define : (*i*) calorie (*ii*) joule (*iii*) specific heat of a substance.

5. Distinguish between
   (*i*) Fusion and Vaporization
   (*ii*) Melting and Boiling
   (*iii*) Evaporation and Boiling
   (*iv*) Melting point and boiling point.
6. What are the factors upon which evaporation depends ?
7. 'Evaporation causes cooling'. Explain this statement and give one experiment to demonstrate that evaporation causes cooling.
8. Give reasons for the following :
   (*i*) Why does ice appear colder than ice cold water and steam appear hotter than boiling water ?
   (*ii*) Water in an earthen vessel attains a lower temperature than the room temperature. Why ?
   (*iii*) Why do dogs hang out their tongue in summer ?
   (*iv*) Why a perspiring person feels more comfortable after sitting under a fan ?
9. What is the meaning of the statement that specific heat of lead is 0.03 cal per gm per °C ?
10. Why does steam at 100°C produce a severe burn than water at 100°C ?
11. (*a*) Can we develop a device based on our sense of touch to measure temperature of a body ?
    (*b*) How would you demonstrate the presence of water vapour in the atmosphere ?
12. Set up an activity to study the heating of ice and water and hence define melting point of ice and boiling point of water with the help of a graph. Identify the solid, liquid and gaseous states on the graph.
13. (*a*) What is the unit of temperature ?
    (*b*) Describe the Celsius scale of temperature.
    (*c*) When a clinical thermometer is taken out of the mouth of a patient, mercury level does not fall on its own. Why ?
14. Wet your finger, hold it up in the air. How would you decide which way the wind is blowing ?
15. Describe how will you determine the melting point of wax or naphthalene by cooling curve method.
16. Describe an experiment to determine the boiling point of water.
17. A Celsius thermometer is placed first in a test tube of boiling water and then into a large can of boiling water. What will it read in each case ?
18. If ice is kept in a place where the surrounding temperature is 0°C, do you think that ice will melt ?
19. Why does wetting the floor of a room sometimes produce a cooling effect on the people in the room ?

20. Does a strong wind help your mother to dry her washing ? What other conditions make for an ideal drying day ?
21. How many joules of heat are needed to increase the temperature of 1 kg of copper by 40 degrees ? Specific heat of copper is 400 J/kg °C.'
22. A glass of 100 ml of water is kept in sunlight for 20 minutes. Its temperature goes up by 3°C. How much heat from the sun reaches the glass in one minute ? Specific heat of water is 4200 J/kg °C.
23. What is meant by the heat capacity of a substance ? In what units is it expressed ?
24. If you supply the same amount of heat to 1 kg of copper are 1 kg of aluminium, which would have the higher temperature ?

□□

CHAPTER 5

EXPANSION CAUSED BY HEAT

5.1 Since heat is a form of energy, it can produce various effects. Expansion is one of the effects of heat. You will learn many more experiments by which this can be demonstrated.

You will learn also that all substances expand on heating and contract on cooling, and they do these to different extents.

We shall then consider to what use we can put the expansion of a solid by heat and the special behaviour of water when it is heated or cooled.

5.2 Expansion of Solids :

You should first try the following experiments and make your deductions from the results you obtain.

Experiment :

To show that solids expand on heating.

Requirements :

Bunsen burner, tripod stand, ball and ring, bar and gauge, metal rod, knitting needle or optical pin, pointer made of a strip of paper, retort stand and clamp, a battery of two accumulators, about 40 cm length of wire, plug key, connecting wires.

Procedure :

(*a*) **Ball and ring experiment.** First try to pass the ball through the ring provided for it (Fig.5.1). Put the ball in the flame for a few minutes. Remove it and try to pass it through the ring again. What happens ? Let the ball cool down and then try again. What happens ?

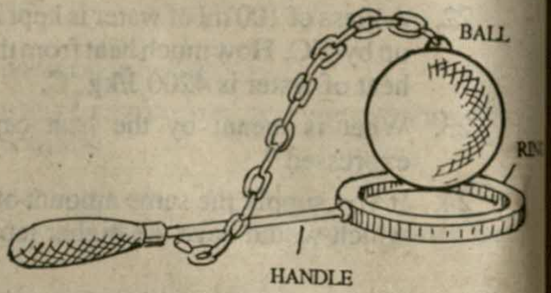


Fig.5.1 Ball and ring experiment.

You will notice that when it is cold th ball passes through the ring, but when ver hot it cannot pass through.

(b) **Bar and gauge experiment.** As i (a), first try to pass the bar through the gaug both side-on through AB (see Fig. 5.2) an end-on through the holes C and D. Now pu the bar in the flame for a few minutes. The try to pass it through again both ways. Wha happens ? Cool it and repeat the process.

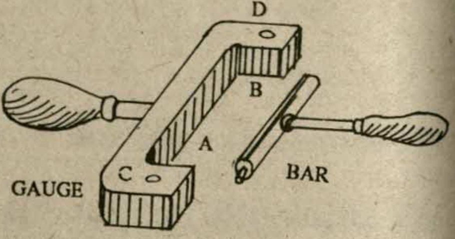


Fig. 5.2 Bar and gauge experiment.

You will observe that when it is cold the bar goes through AB side-on and throug C and D end-on, but when hot it cannot g through in either direction.

(c) Clamp a metal rod horizontally and let its free end rest on a knitting needle o optical pin placed on a smooth block o

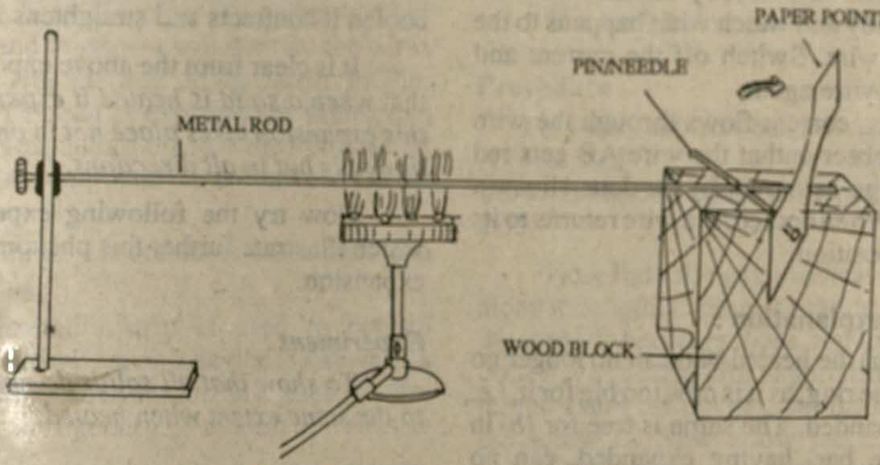


Fig. 5.3 To show expansion in solids.

wood. Fix a light paper pointer on the needle and make the pointer point upwards (Fig. 5.3). Now heat the rod all along its length and watch what happens to the pointer.

Now remove the flame and let the rod cool down. Watch what happens to the pointer again.

You will see that as the rod is heated the pointer starts to rotate in the direction of the hands of the clock according to Fig.5.3. When the rod cools down the pointer will rotate back to its original position.

(d) Stretch the wire AB across two stands. Connect the two ends of the wire to a battery and a key with connecting wires (Fig. 5.4.). Before closing the key see that

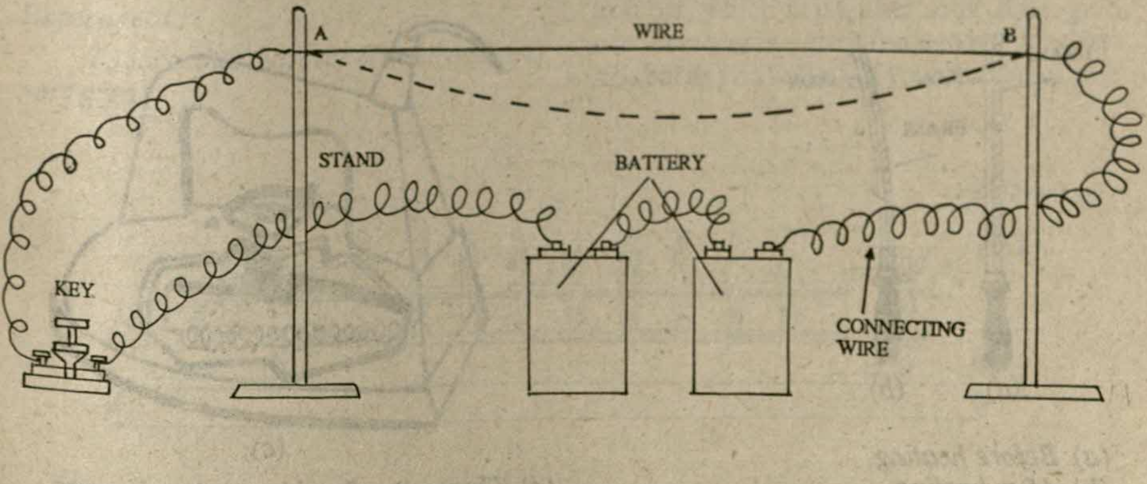


Fig. 5.4 To show that solids expand on heating, using electrical apparatus.

the wire AB is perfectly horizontal. Now close the key and watch what happens to the stretched wire. Switch off the current and watch the wire again.

When current flows through the wire you will observe that the wire AB gets red hot and sags, as shown by the dotted lines in Fig. 5.4. When cooled, the wire returns to its original position.

General explanation :

In (*a*) the heated ball can no longer go through the ring, as it is now too big for it, *i.e.*, it has expanded. The same is true for (*b*) in which the bar, having expanded, can no longer go through the gauge. When cooled, each of them contracts to its former size and is able to go through.

In (*c*) the rod expands, and as it expands it makes the needle or pin on which it rests roll on the smooth block of wood. As the needle rolls, the paper pointer attached to it rotates. Thus, you see, the metal rod has expanded on heating. When cooled it contracts and rolls the pin back.

In (*d*) the wire gets hot and expands. Since it is fixed at A and B, it cannot expand in either direction, and so it sags. When cooled it contracts and straightens itself.

It is clear from the above experiments that *when a solid is heated it expands, and this expansion takes place not in one direction only but in all directions.*

Now try the following experiments which illustrate further this phenomenon of expansion.

Experiment :

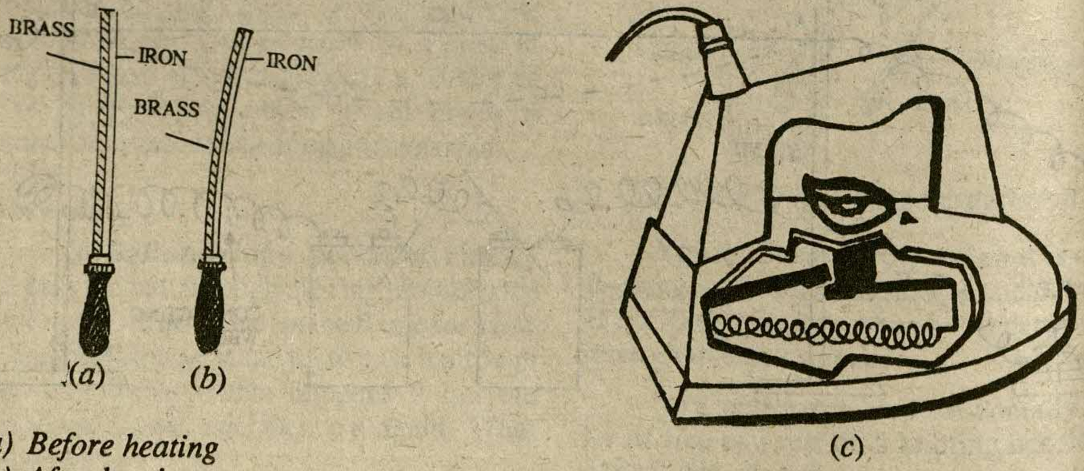
To show that all solids do not expand to the same extent when heated.

Requirements :

Compound bar (or bimetallic strip) of two metals, bunsen burner. The compound bar consists of two blades of two metals (*e.g.*, iron and brass) of equal length and equal thickness smoothly riveted together (Fig. 5.5).

Procedure :

First examine the compound bar and see that the blade is perfectly flat. Now put it in the flame for a few seconds. What happens ?



(a) Before heating
(b) After heating

(c) Thermostat fitted in an electric press

Fig. 5.5 A compound bar or bimetallic strip.

You will notice that the compound bar becomes bent. If the bar is a compound bar of iron and brass you will see that the bar is bent towards the iron sid, as shown in Fig. 5.5 (b). This can be explained by saying that the brass expands more than the iron and that is why the compound bar is bent towards the iron side.

Similarly it contracts more than iron on cooling.

Bimetallic strip is used to control temperature and such a device is known as a *thermostat*. Thermostats are used in fire alarms, refrigerators, automatic electric presses etc.

Fig. 5.5 (*c*) shows a thermostat fitted in an electric press. When the temperature rises the strip bends upwards and breaks the circuit. When it cools down the circuit is again completed. The gap width is controlled by a knob on the top of the press. The size of this gap governs the length of time the iron is off and hence the average temperature of the press.

All solids expand on heating, but the extent to which they expand is different for different solids.

Experiment :

To show that the force of contraction is very great.

Requirements :

The bar breaker, cast-iron bars, water.

Procedure :

Pass the cast-iron bar through the hole A provided for it in the apparatus as shown in Fig. 5.6. Screw the apparatus tightly at D.

Now light the gas and heat the bar all along its length. Continue heating, and when the screw D becomes loose, tighten it. When you have heated for approximately ten minutes turn off the gas and further tighten the screw D. Now allow the bar to cool down. If you like, pour cold water on it to make it cool more rapidly. Move back and observe what happens.

You will see that in a few minutes the cast-iron bar will break with a loud bang and the pieces will scatter. This is why you must move back.

Explanation :

The iron bar B expands on heating. When it is later cooled it contracts. One end has been fixed by screw D, and the other end A is prevented from contracting by the cast-iron bar, which must, after some time, give way. It requires a great force to break a cast-iron bar as you will see if you try to break one

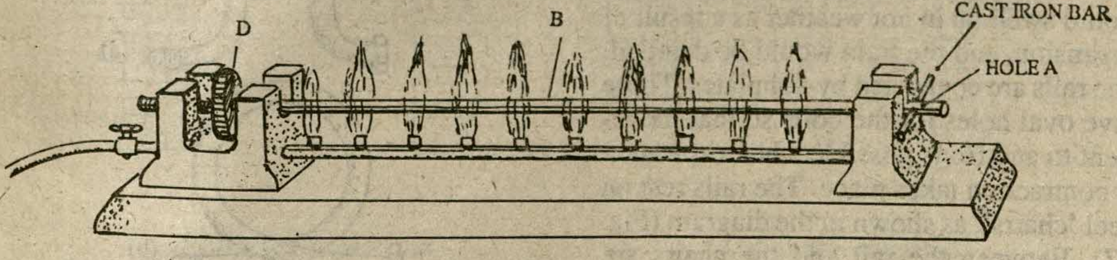


Fig. 5.6 A bar breaker.

yourself. You can therefore imagine how great the force of contraction is. Below is given a list of a few solids in order according to their expansions.

Suppose a length of iron expands by 2.54 cm when heated through 50°C, the following metals will expand by the amounts shown against their names when equal lengths of them are heated through the same temperature :

Aluminium	5.0 cm approximately
Brass	4.0 cm approximately
Copper	3.6 cm approximately
Glass	1.8 cm approximately
Pyrex glass	0.76 cm approximately
Invar	0.2 cm approximately

A few applications on the effects of expansion of solids

In our everyday experience we find that the expansion and contraction of substances sometimes cause us trouble or even danger, and so we have to devise ways of avoiding these difficulties. A few of these devices will be discussed here. You will learn others later.

1. Railway lines.

Railway lines expand when the weather is hot and contract during cold weather. They are, therefore, laid down in lengths with gaps between one rail and the next to allow them to expand and contract freely. Without a space between the rails, the joints would swell up in hot weather as a result of expansion, and the train would be derailed. The rails are connected by fishplates. These have oval holes for the bolts so that movement to and fro is possible when expansion or contraction takes place. The rails rest on steel 'chairs', as shown in the diagram (Fig. 5.7). Between the rail and the chairs are wooden wedges which keep the rail in position. These wooden wedges are sufficiently soft to allow the rail to expand sideways.

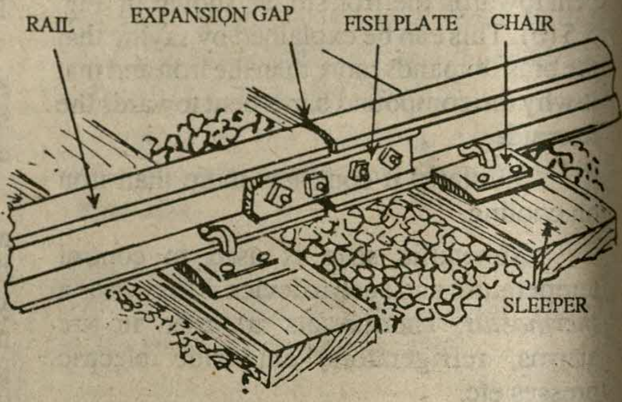


Fig. 5.7 Arrangement to allow for expansion and contraction of railway lines.

2. Expansion loops in pipes.

In several factories and workshops where steam is passed through pipes the steam pipes are fitted with loops, as shown in Fig. 5.8. These loops allow the pipe to expand easily when hot steam is passing through and contract when it cools down. Without the loops, the pipes tend to expand at the joints, which become loose, causing leakage or bursting of the pipes.

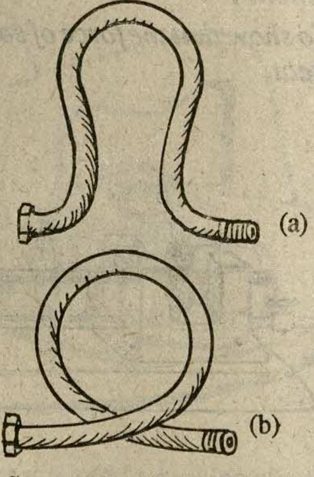


Fig. 5.8 Steam pipe expansion loops.

We have shown experimentally that the force of expansion is very great. All substances exert great forces if one tries to stop them expanding or contracting. These forces are often used to tighten some things and to push others. We shall discuss two of these.

3. Locomotive wheels.

Locomotive wheels are fitted with iron tyres. These tyres are made a little smaller than the wheels. They are first heated until red hot, during which they expand and can easily be slipped on to the wheels. On cooling they contract and grip the wheels firmly.

4. Rivetting.

The plates of a ship and the sheets of a boiler can be firmly joined together by using rivets. The rivet is inserted red hot through holes opposite each other (see Fig. 5.9, stage 1) in the two plates. The rivet is now hammered flat while still red-hot (stage 2) and then left to cool. As it cools it contracts and binds the plates firmly together (stage 3).

5. Steel bridges :

These expand during hot weather and contract during cold weather. If the bridge is fixed at both ends, as shown in Fig. 5.10 (*a*), you can well imagine what will happen in hot weather [see Fig. 5.10(*b*)]. To avoid this, long steel bridges are built so that the ends of the steel structures rest on rollers which allow the bridge to expand or contract with-

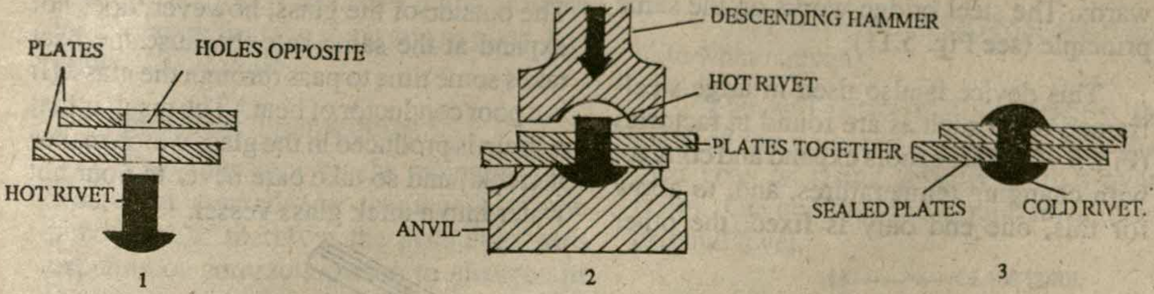
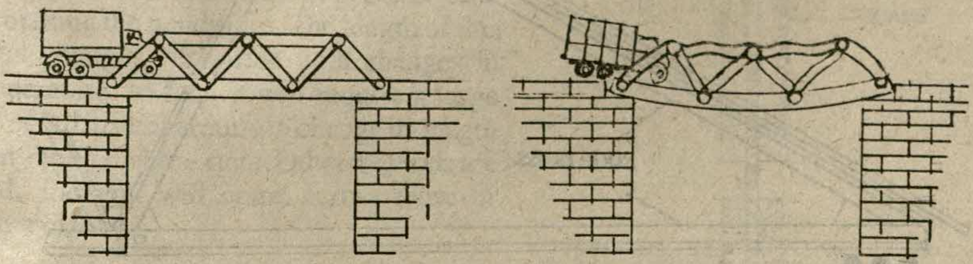


Fig. 5.9 Rivetting in three stages.



(*a*) *Before expansion*

(*b*) *After expansion*

Fig. 5.10 Expansion of a bridge in hot weather.

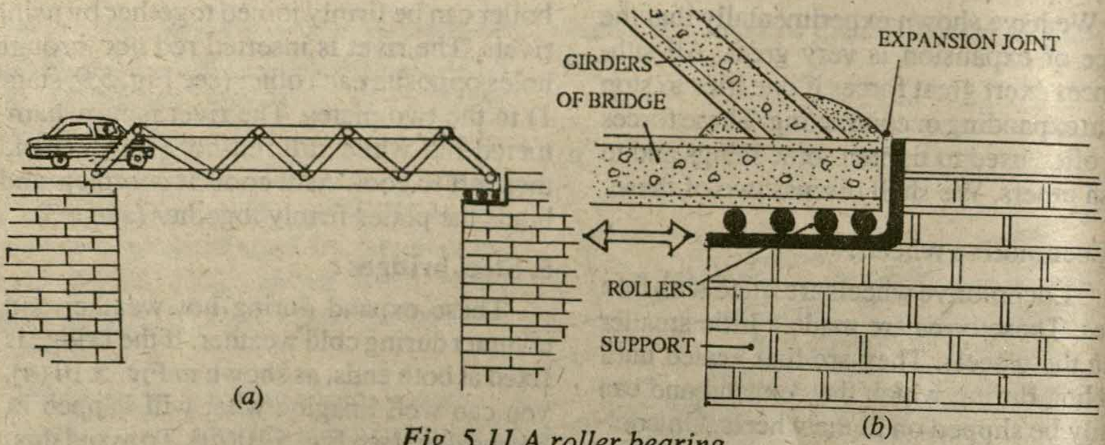


Fig. 5.11 A roller bearing.

out weakening the structure. You will probably remember an experiment described earlier in this chapter in which the expansion and contraction of a metal rod resting on a pin made the pin roll forwards and backwards. The steel bridge works on the same principle (see Fig. 5.11).

This device is also used in large steel-framed roofs such as are found in factories (Fig. 5.12). These roofs expand and contract with changing temperatures, and, to allow for this, one end only is fixed, the other resting on either a rocker or a roller.

6. Expansion of glass :

When hot water is poured into a thick glass tumbler, the inside expands rapidly. The outside of the glass, however, does not expand at the same rate, because the heat takes some time to pass through the glass. (It is a poor conductor of heat.) The result is that a strain is produced in the glass which makes it crack ; and so take care never to pour hot water into a thick glass vessel.

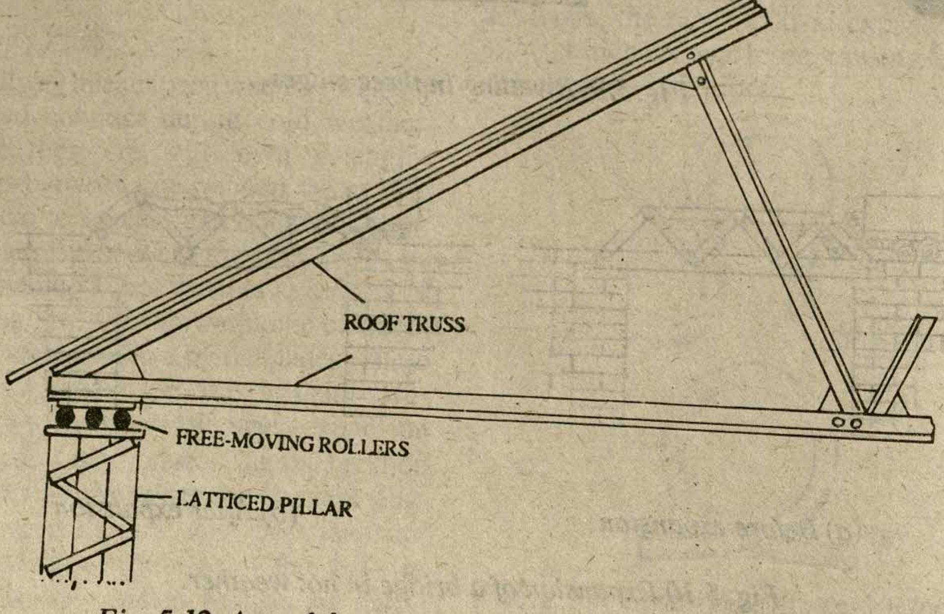


Fig. 5.12 A steel-framed roof showing roller arrangements.

Nowadays, a type of glass known as *Pyrex* is used for making glass vessels such as beakers and flasks used in the laboratory. This material expands only slightly on heating, and so vessels made of such materials can hold hot liquids without cracking. *Vitreosil* and *quartz* are other substances having the same property as Pyrex. They are used in making cooking utensils.

The filaments inside electric-light bulbs must be connected to the outside wiring for the lamp to be used, and this means that the wires must pass through the glass. For this purpose a substance must be found for the filament which would expand to the same extent as glass to prevent cracking from unequal expansion. Platinum may be used, but it is expensive. An alloy of nickel and steel (45% nickel) has been found suitable which expands at the same rate as glass. It is known as *platinite*.

7. Compensated pendulums :

The time kept by the swinging of a pendulum depends on the length of the pendulum. If therefore the pendulum wire expands or contracts owing to changes in temperature it is clear that the pendulum will not always keep correct time. There are devices whereby this can be remedied. For instance, a metal known as *invar* can be used for making the pendulum. The length of this metal changes very little with changes in temperature. In fact, it will require a large rise or fall in temperature to change its length to any appreciable extent. Other methods are used, and you will come across these in higher classes.

5.3 Expansion of Liquids :

Try the following experiment.

Experiment :

To show that a liquid expands on heating.

Requirements :

Round-bottomed flask, or conical flask, fitted with rubber bung and a fairly long piece of glass tubing ; coloured liquid, scale, water bath.

Procedure :

Fill the flask to the brim with the coloured liquid. Fit in the rubber bung so that a good length of the glass tubing is outside the flask. Add a bit of the coloured liquid until the length of the liquid shows in the glass tubing. With the aid of a paper scale fixed on the tubing (Fig.5.13) mark the original level of the liquid in the tubing. Now place the flask inside a hot-water bath. Watch the level of the coloured liquid in the tubing. What do you notice ?

Allow the apparatus to cool down and note what happens.

You will notice that, on heating, the level of the coloured liquid first falls and then goes on rising steadily until it overflows. On cooling, the liquid falls to its original level.

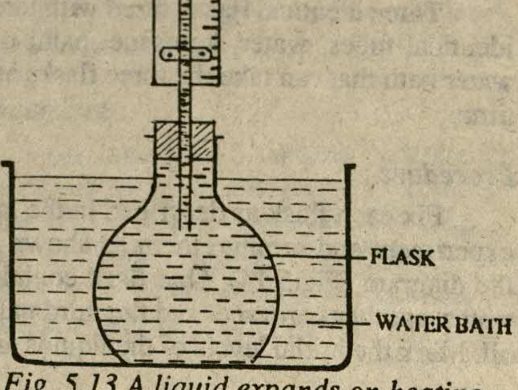


Fig. 5.13 A liquid expands on heating.

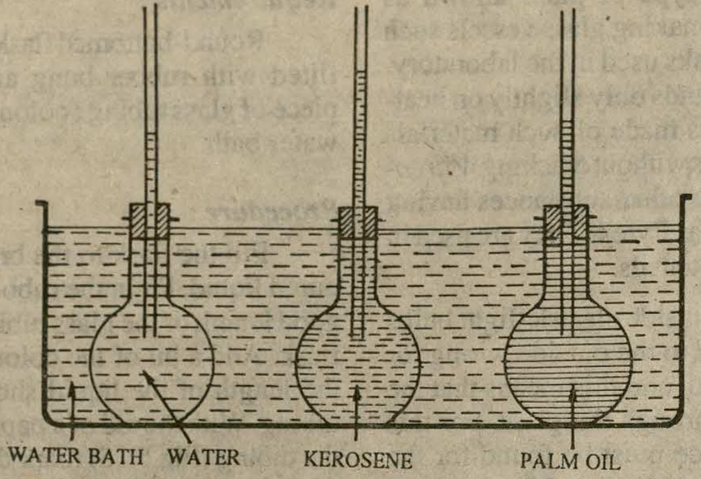


Fig. 5.14 Comparison of expansion of different liquids.

Explanation :

The level of the liquid first falls, because the glass flask, being first affected by the heat, expands, providing more space for the liquid. The continuous rise of the liquid that follows shows that the liquid is expanding as it also is being heated.

The fall in the level when the apparatus is cooled shows that *the liquid contracts on cooling.*

Experiment :

To show that all liquids expand by different amounts on heating.

Requirement :

Three identical flasks fitted with three identical tubes, water, kerosene, palm oil, water bath that can take the three flasks at a time.

Procedure :

Fix each flask as described in the last experiment and arrange them as shown in the diagram (Fig.5.14). One flask contains water, another kerosene and the third palm oil. Mark the initial levels of the liquids and then the final levels, after they have remained for a few minutes in a water bath whose temperature does not exceed 65°C

(Why is it not advisable to go beyond this temperature ?)

You will notice the original fall in the level of each liquid and the continuous rise that follows it. There is a rise in each case, but the final levels of the liquids in the tube are not the same. This shows that while all liquids expand on heating, they expand to different extents.

Try to arrange the three liquids used in the above experiment in the order of their expansion.

Below is given a list of liquids in order of the extent to which they expand.

Suppose a volume of mercury expands by 1 cc when heated through 50°C, then the same volumes of the following liquids will expand by the amounts shown against them when heated through the same temperature.

Alcohol	6.0 cc approximately
Turpentine	4.8 cc approximately
Kerosene	4.4 cc approximately

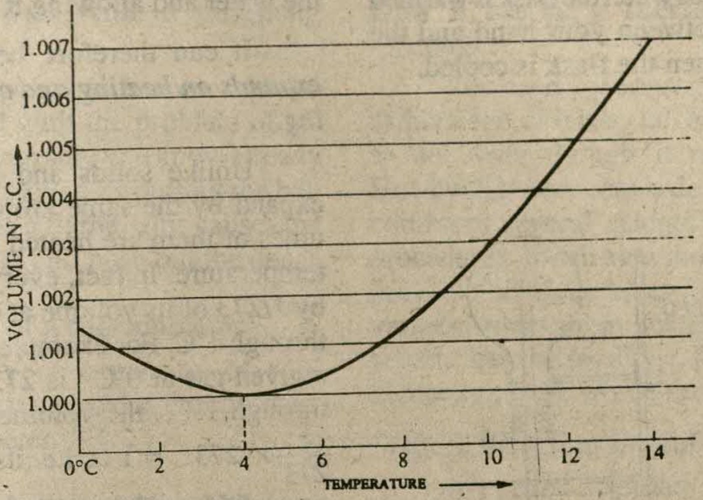


Fig. 5.15 Graph to show the peculiar behaviour of water.

The expansion and contraction of water

The way water expands and contracts is so unusual that we must make special mention of it.

If water at about 100°C, (*i.e.*, boiling water) is gradually cooled in a vessel to which some long glass tubing has been fixed, it will be seen that the level of the water in the tubing will gradually fall until it is cooled to 4°C. If it is cooled further the level will start to rise until the temperature reaches 0°C. This shows that water contracts when cooled from 100°C, until 4°C, when it starts expanding. The following graph (Fig. 5.15) of volume against temperature shows what has been outlined above.

The outlined experiment shows that a given mass of water has its least volume and hence *highest density* at 4°C.

Nobody knows why water behaves like this, but because of this behaviour ponds start to freeze, not from the bottom, but from the top, while the bottom of the lake remains at 4°C, a temperature warm enough to preserve the lives of fishes and other water animals during the cold winter.

You will learn more about this in the higher classes.

5.4 Expansion of Gases:

Try the following experiment.

Experiment :

To show that a gas expands when heated.

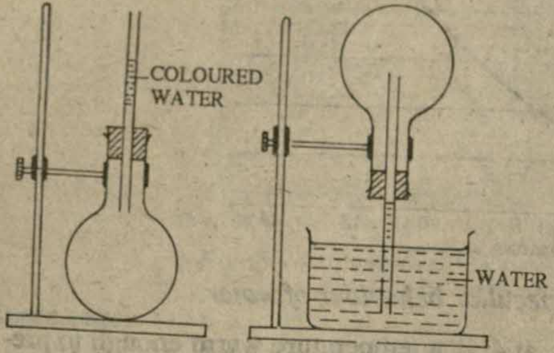
Requirements :

A round-bottomed flask fitted with cork and glass tubing, retort stand and clamp, a beaker of water.

Procedure :

(*a*) Introduce a column of coloured water into the glass tubing and fit it into the flask [Fig. 5.16(*a*)]. Hold the flask in your hand and rub it very gently. What do you notice ? Cool the flask by placing it on the table and see what happens.

You will observe that the column of coloured water rises when the flask is warmed by the friction between your hand and the flask and falls when the flask is cooled.



(a) (b)

Fig. 5.16 Expansion of air on heating.

(*b*) Fit up the apparatus as shown in Fig. 5.16(*b*). Gently warm the bottom of the flask with the palm of your hand or with a low flame and note what happens. Now cool the flask and again watch what happens.

You will notice that air bubbles into the water from the glass tubing as long as heating continues, but when the apparatus is cooled, water starts to rise inside the tubing and continues to rise as cooling continues.

Both experiments have shown that *air expands on heating*.

In (*a*) the air in the flask expands and pushes up the column of water, and when it is cooled it contracts, thereby allowing the water column to return to its original position.

In (*b*) the air in the flask expands on heating and bubbles out of the water. On cooling, the air contracts, leaving room for the water and allowing it to rise.

It can therefore be said that a *gas expands on heating and contracts on cooling*.

Unlike solids and liquids, all gases expand by the same amount if equal volumes of them are heated through the same temperature. In fact, every gas will expand by 1/273 of its volume at 0°C, when heated through 1°C. For example, if the volume of a given gas at 0°C is 273 cc when heated through 1°C, the volume will increase by $\frac{1}{273} \times 273 = 1$ cc *i.e.*,its volume will become 274 cc.This will happen only if the pressure of the gas remains unchanged.

5.5 Expansion of solids, liquids and gases :

The expansion of a solid is so small that we need something to magnify the change before we can see it. In the case of liquids and gases the amoun[illegible]ion can be seen with the naked [illegible] expansion of gases is general[illegible]gner than that of liquids. For instance, a gas expands as much as about twenty times that of mercury and about eight times that of water.

5.6 Applications of expansion of gases :

1. Air thermometers :

Because of their rapid expansion, gases are used in certain forms of thermometer to measure temperatures very accurately within a wide range. Such thermometers are known as air or gas thermometers. They are so accurate that they are used as a standard for all other types of thermometers. You will learn more about them later in your study of physics.

2. Removing a dent from a pingpong ball :

Often a pingpong ball becomes dented and you are faced with the problem of removing the dent. I am sure you know already that dent can be removed by putting the ball in hot water or near a flame. This causes the air inside to expand and push out the dent.

5.7 Construction of a thermometer :

The property of expansion of substances on heating is utilised in the construction of a thermometer.

Liquids used for making thermometers :

Because liquids expand on heating and contract on cooling, some of them whose expansion and contraction are regular are used for measuring temperature. Mercury and the alcohol are the commonest. In most thermometers mercury is the liquid used. This is because it has the following distinct advantages over all other liquids for this purpose :

(*i*) It can be seen easily through glass.

(*ii*) It does not wet its container *i.e.*, when mercury rises to a level in the tube and then falls to a lower level it does not leave drops on the tube as water does.

(*iii*) It can be used for a large range of temperatures, as it melts at —39°C and boils at 357°C.

(*iv*) Its expansion is uniform.

(*v*) It quickly assumes the temperature of anything with which it is in contact.

Another liquid that is used is alcohol, but it has to be coloured with a dye so that one can see it through glass. Since it has a low melting point (–112°C), it is generally used for measuring low temperatures. It boils at 78°C.

How a mercury thermometer is constructed :

You need not construct a thermometer at this stage, as it is by no means an easy thing to do, even though it might appear so. However, the process is described because it combines several scientific principles and procedures. It will also show you what great pains the scientist takes in constructing his various measuring instruments. If your teacher has the facilities, he may be able to demonstrate the whole process to you.

Stage I. Selecting the tube.

A narrow capillary tube should be selected in order that the slightest expansion of mercury caused by a small rise in temperature may be shown clearly in the tube. The tube should be about 25 cm. long. It must have a uniform bore. To test this, a small amount of mercury is introduced into the tube and its length is measured at different parts of the tube (Fig. 5.17). The lengths must be the same if the tube is of uniform bore.

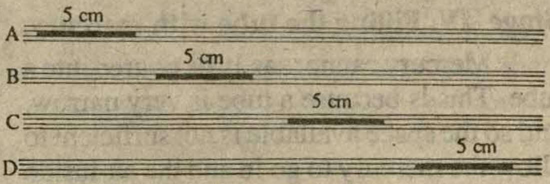
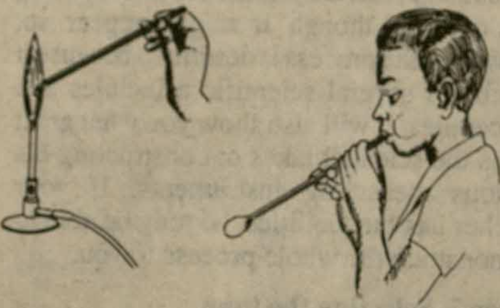


Fig. 5.17 To test if the bore of a tube is uniform.

Stage II. Cleaning the tube.

The tube is probably greasy. Therefore it is placed in nitric acid (the acid is never touched with the fingers, as it burns) and then in caustic soda. It is then washed away with distilled water and very carefully dried.



(*a*) (*b*)

Fig. 5.18 Blowing the bulb of a thermometer tube.

Stage III. Blowing the bulb.

One end of the tube is placed in a bunsen flame and heated until it melts [Fig. 5.18(*a*)]. Air is blown in from the cold end until the melted end forms a bulb [Fig. 5.18(*b*)].

Stage IV. Filling the tube with mercury.

Mercury cannot easily be poured into a tube. This is because a tube is very narrow, and so the space available is not sufficient to allow the mercury to go in and the air inside to come out. The tube is therefore filled by alternate heating and cooling. A small funnel is attached by rubber tubing to the open end of the tube and some mercury is poured in (Fig. 5.19). The tube is heated gently with a flame.

This causes the air inside to expand and bubble out through the mercury. The flame is removed. As the tube cools down, the air contracts and mercury drops in to replace the air that has escaped. The heating and cooling are continued until the whole tube is filled.

The tube is now heated slightly beyond the highest temperature we want it to measure. As it is heated, the mercury expands and overflows. At this temperature a blow lamp is used to seal the top. This is by no means an easy task. The tube is now cooled, and the mercury contracts, leaving a vacuum above it.

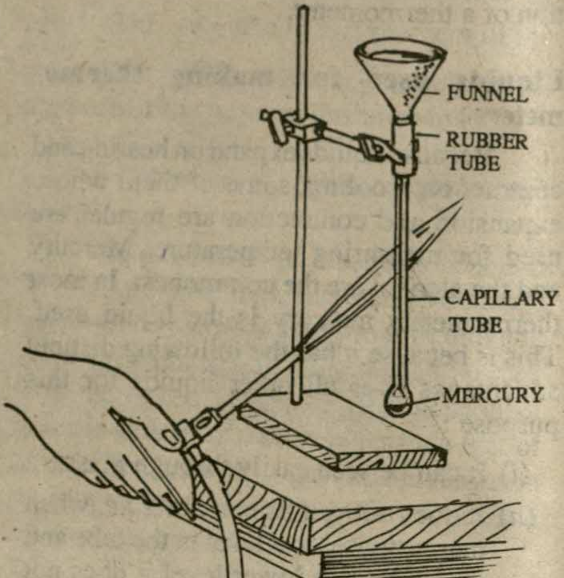


Fig. 5.19 Filling a thermometer tube with mercury.

Stage V. Marking the upper and the lower fixed points.

The thermometer has now actually been constructed, but to make it useful the stem must be graduated. To graduate anything at all, two fixed points must be obtained, the distance between them can then be sudivided in any way we like. In graduating a thermometer the two fixed points chosen are those of melting ice (lower fixed point) and

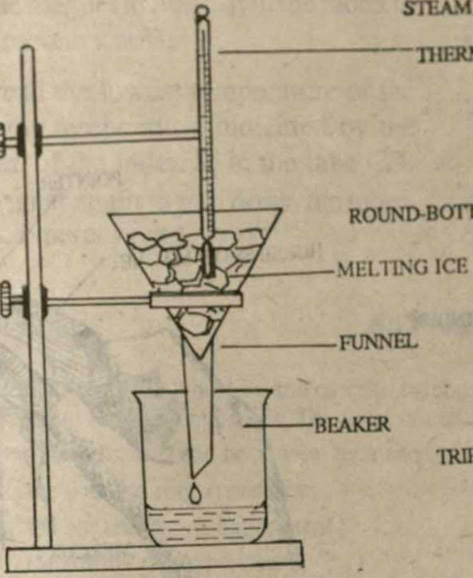


Fig. 5.20
Marking the lower fixed point of a thermometer,

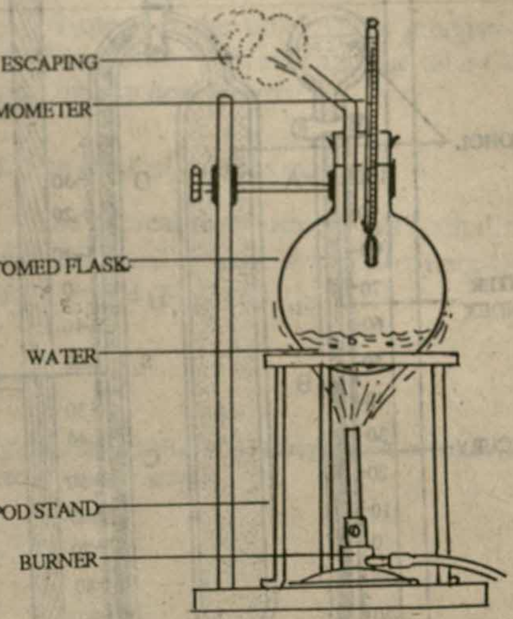


Fig. 5.21
Marking the upper fixed point of a thermometer.

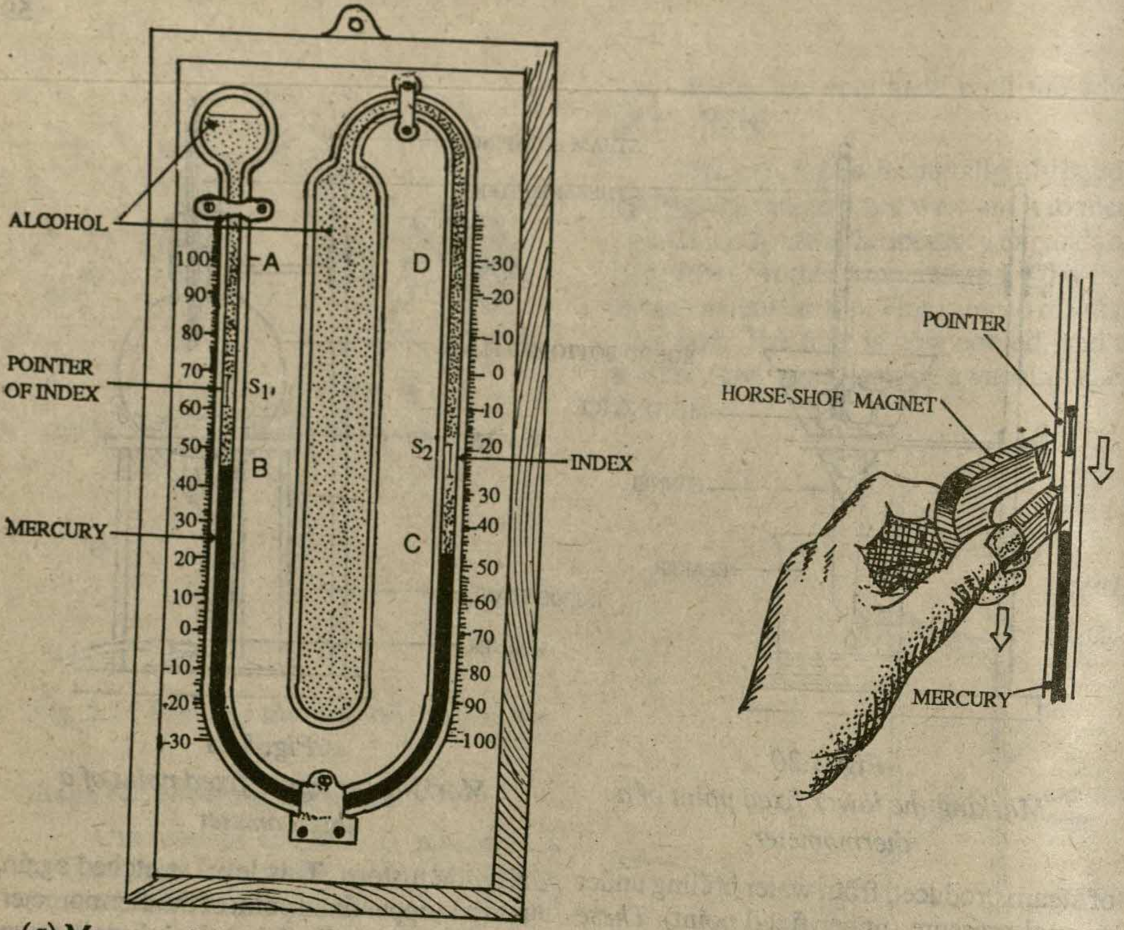
of steam produced from water boiling under normal pressure (upper fixed point). *These two are chosen because, under normal conditions, they never change.*

To mark the lower fixed point, the tube is vertically suspended so that its bulb is completely covered by melting ice packed into a funnel (Fig. 5.20). A small receiver is placed below the funnel to catch the water as the ice melts. The level of the mercury falls rapidly at first and then slowly. When it stops falling a mark is etched (scratched) on the tube to mark the level of mercury. This point is the lower fixed point.

To mark the upper fixed point, the tube is mounted over water in a round-bottomed flask, as shown in Fig. 5.21. The water in the flask is heated until it boils. Steam is formed, and it surrounds the bulb of the tube. The level of the mercury in the tube rises gradually, then stops. This level is etched again, and it is upper fixed point of the thermometer. *Note that the bulb of the tube is kept in steam and not in boiling water, because* whereas the temperature of steam is not affected by impurities present in the water, the boiling point of water is. Note also that there is another tube in the flask. It is through this that steam escapes.

Stage VI. Graduation or calibration.

Having marked on the tube the upper and lower fixed points of the thermometer, we are now ready to divide the space between these two points into a *number of equal divisions*. This can be done in a number of ways, but there are two particular scales of division in common use : one, called *Centigrade*, has one hundred divisions or degrees between the two fixed points;



(*a*) Mercury rising in the thermometer.

(*b*) The horse-shoe magnet.

Fig. 5.22 A maximum and minimum thermometer.

while the other, called the *Fahrenheit,* has one hundred and eighty divisions (Fig.4.5).

5.8 Types of Thermometers :

The type of thermometer that has been described above is the common and simple thermometer.

There are several other types of thermometers, but we shall at this stage study only two of them : Six's maximum and minimum thermometer and the clinical thermometer.

1. The Six's maximum and minimum thermometer :

This thermometer is used to register the highest and the lowest temperatures for the day. As the mercury in the thermometer [Fig. 5.22(*a*)] rises or falls it pushes up one of the small steel pointers or indices. (plural of index) S_1 and S_2 . A small spring is attached to each index to prevent it being pulled down when the mercury falls. A horse-shoe magnet [Fig. 5.22(*b*)].is used to pull the index back to touch the mercury when readings have been taken.

To read the highest temperature of the day, look at the steel index S_1 in the tube AB and read the temperature indicated by the *bottom end* of the index. This gives the highest temperature for the day. You can then use the magnet to pull down the index to touch the mercury at B.

To read the lowest temperature of the day, read the temperature indicated by the *bottom end* of the index S_2 in the tube CD. Use the magnet again to pull down the index to touch the mercury at C.

Note that the tube AB is graduated from the bottom upwards and the tube CD from the top downwards.

2. The clinical thermometer.

The clinical thermometer has been discussed in detail on page 28 and 29 of item 4.4 of Chapter 4 (Fig. 4.6)

Summary

1. All solids expand on heating and contract on cooling but the extent to which they expand or contract is different for different solids. The force of contraction is very great.
2. Expansion of solids can be shown by means of :
   - (*a*) the ball and ring experiment ;
   - (*b*) the bar and gauge experiment ;
   - (*c*) the rolling pin experiment ;
   - (*d*) an electric wire carrying a current.

3 Expansion of solids has numerous applications in daily life *viz*., rivetting ; fixing the metal tyres on the wheels in locomotives ; compensated pendulums ; a compound bar etc.,etc.

4. Expansion and contraction of substances, sometimes cause us trouble or even danger, and so we have to devise ways of avoiding these difficulties. For example by leaving a gap in railway lines ; by providing rollers under free end of a bridge ; by leaving telegraph lines loose in summer ; by using thin-walled glass tumblers for pouring hot liquids in them etc.,etc.
5. Liquids and gases also expand when heated and contract when cooled.
6. The property of expansion of liquids and gases on heating is utilized in the construction of a thermometer.
7. Mercury and alcohol are used in thermometers owing to their expansion properties. Some gases, too, are used in air or gas thermometersMercury has advantages over all other liquids. Alcohol is used for lower temperatures.
8. Whereas liquids expand to *different* extents, all gases expand to the *same* extent *i.e.*,by $\frac{1}{273}$ of their volume at 0°C at constant pressure.
9. Water has a peculiar behaviour which accounts for ponds freezing from the top in winter.
10. The fixed points in a mercury thermometer are determined by melting point of pure ice and boiling point of water under normal pressure.
11. To construct a mercury thermometer, the following stages are necessary :
    - (*i*) Selecting the tube
    - (*ii*) Cleaning the tube
    - (*iii*) Blowing the bulb
    - (*iv*) Filling the tube with mercury
    - (*v*) Marking the upper and lower fixed points
    - (*vi*) Graduation or Calibration.

12. The two scales of temperature commonly used are :

    (*a*) Centigrade : lower fixed point 0° ; upper 100°

    (*b*) Fahrenheit : lower fixed point 32° ; upper 212°

    One can be converted into the other by calculation $\frac{C}{100} = \frac{F-32}{180}$

13. There are several different types of thermometers. Two of them are :

    (*a*) Six's maximum and minimum thermometer used to measure the highest and lowest temperatures of the day.

    (*b*) The clinical thermometer used by doctors to measure temperatures of patients.

Questions

(A) Objective Type Questions :

1. Fill in the blanks :

    (*i*) All substances .... on heating and .... on cooling, and they do these to .... extents.

    (*ii*) When a solid is heated it .... and this .... takes place not in one direction only but in .... directions.

    (*iii*) All substances exert great .... if one tries to stop them expanding or contracting.

    (*iv*) Now-a-days, a type of glass known as .... is used for making glass vessels such as beakers and flasks used in the laboratory.

    (*v*) While all liquids .... on heating, they .... by .... amounts when heated through the same temperature.

    (*vi*) A given mass of water has its .... volume and hence highest .... at 4°C.

    (*vii*) All gases expand by the .... amount if equal volumes of them are heated through the same temperature.

    (*viii*) Expansion of gases is generally much .... than that of ....

    (*ix*) In the Centigrade scale, the lower fixed point is called .... and the upper fixed point .... and the space between them is divided into .... degrees.

2. State whether the following statements are true (T) or false (F) :

    (*a*) All solids expand to the same extent when heated.

    (*b*) The expansion and contraction of substances do not cause any trouble at all.

    (*c*) Vitreosil and quartz are substances having the same property as pyrex and they are used in making cooking utensils.

(*d*) Alcohol, turpentine and kerosene expand by different amounts on heating through the same range of temperature.

(*e*) Water expands and contracts in an unusual manner.

(*f*) Every gas will expand by 1/273 of its volume at 0°C when heated through 1°C.

(*g*) In graduating a mercury thermometer, the melting point of ice is chosen as its lower fixed point.

3. Match the following and write the complete sentences :

	Column A		**Column B**
(*i*)	Mercury boils at	(*i*)	100°C
(*ii*)	Brass expands more than	(*ii*)	Iron
(*iii*)	Expansion of liquids and gases is used	(*iii*)	in making a thermometer
(*iv*)	Centigrade scale has a upper fixed point as	(*iv*)	375°C

(B) Very Short Answer Type of Questions.

1. Mention the names of two useful devices based on expansion of solids.
2. What formula can be used to convert Celsius temperature to Fahrenheit temperature.
3. Name one liquid which is used in making a liquid thermometer.
4. What is the freezing point of water on the Fahrenheit scale ?
5. A metal plate has a circular hole. Will the diameter of the hole increase or decrease on heating this plate ?
6. Do all gases expand by different amounts on heating keeping the pressure constant ?

(C) Short Answer Type and Essay Type of Questions

1. Why is mercury the best liquid for a thermometer ? Why is water considered unsuitable ?
2. Name two scales of temperature and state the upper and lower fixed points of each. Describe how these points are obtained on an ungraduated thermometer ?
3. Draw and label fully a clinical thermometer.
4. Why is a clinical thermometer not sterilised in boiling water like the other instruments used in the hospital ?
5. What makes it still possible for clinical thermometer to register the temperature of the body after it has been taken out of the mouth or armpit ?
6. Write out in outline the processes you have to go through in constructing a mercury thermometer.
7. In marking the upper fixed point of a thermometer why must the bulb of the thermometer not touch the water ?

8. Draw and label a maximum and minimum thermometer. What is the purpose of the magnet in Six's maximum and minimum thermometer ?
9. Give one experiment to show that solids expand on heating and one to show that all solids do not expand to the same extent on heating. Illustrate with diagrams.
10. How would you show that liquids expand on heating ? Is it true to say that all liquids expand to the same extent when heated ?
11. A compound bar is made of iron and brass. When the bar is heated to what side will it be bent ? Mention one practical application based on this principle.
12. Why are gaps left between railway lines ?
13. Why are concrete roads marked off into blocks and the cracks filled with tar ?
14. When a glass stopper sticks to the bottle so that it is difficult to remove, what would you do to remove it easily and why ?
15. Which is more likely to break when put in boiling water and why : a thick glass vessel or a thin one ?
16. When electric wires are being strung on poles on a hot day, should they be drawn very tight or be allowed to sag ? Why ?
17. The thermostat controls the temperature of the electric iron ; can you explain how it works ?
18. What is a bimetallic strip ? How does it provide an automatic make and break in an electrical circuit ?
19. (*a*) What is the Celsius scale of temperature ?

    (*b*) What is the unit of temperature on Absolute or Kelvin scale ?
20. A brass disc fits a hole in a steel plate at 20°C. In order to make the disc drop out of the plate, should the disc and plate combination [illegible] or cooled ?
21. Mention some of the practical applications of

    (*i*) expansion of solids

    (*ii*) expansion of liquids.
22. How would you demonstrate that gases expand on heating ? Can expansion of gases be used for making thermometers ?
23. Why does a *poori* swell up on frying ?

□□

CHAPTER 6

TRANSFER OF HEAT

6.1. Flow of Heat Energy (Transfer of Heat) :

Heat energy always flows from a higher temperature to a lower temperature, irrespective of the quantity of heat energy at each level. The flow of heat energy continues until the two temperatures are equal. The temperature at which two bodies in thermal contact with each other do not exchange any heat is called *neutral* or *equilibrium* or *common temperature.*

***Activity*: To plot the heating curve for ice :**

Take some ice and crush it. Put it into a beaker and insert a thermometer so that it is well inside the ice but it does not touch the bottom of the beaker. Take readings of temperature and time every minute. Plot the graph of your results. You should obtain a curve of the type shown in Fig. 6.1.

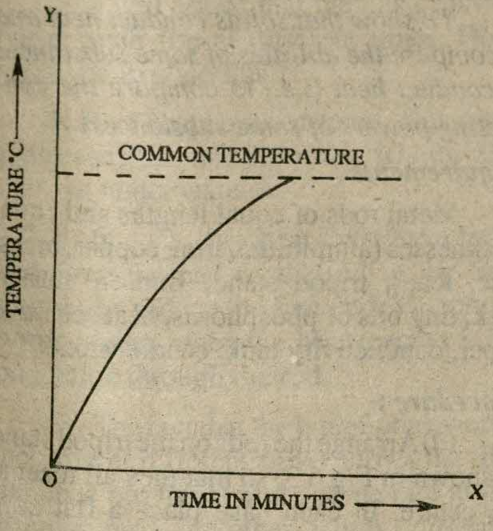


Fig. 6.1

The air in the room surrounding the beaker containing ice is at a higher temperature than the temperature of ice and hence heat flows from the surroundings to ice and then water till both attain a common or neutral temperature.

***Activity* : To plot a cooling curve for water:**

Take some hot water (say at 95°C) in a beaker and arrange to insert a thermometer so that it is well inside the hot water but does not touch the bottom of the beaker. Allow the hot water to cool and take readings of temperature and time every minute. Plot the graph of your results. You should obtain a curve of the type shown in Fig. 6.2

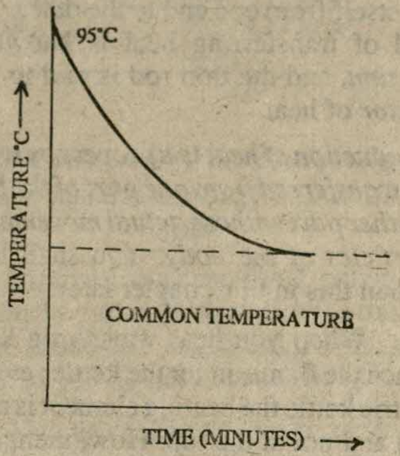


Fig. (6.2)

Hot water loses heat to the surroundings and hence the temperature of water falls with time. This would continue till the water and the surroundings attain a common temperature.

The flow of heat energy from a body (or from a part of the same body) at a higher temperature to a body (or to a part of the same body) at a lower temperature is called *transfer of heat*.

6.2. Processes of Heat Transfer :

(*Modes of Transfer of Heat*)

Heat travels from one place to the other in three ways. The following simple illustrations will enable you to understand the difference between them before we start dealing with each of them in detail.

1. Hold one end of a thin metal rod and dip the other end in a flame. In a few seconds the end which you are holding becomes hot and you drop it. How has the heat got to your hand ? If you feel the rod all along its length before the heat gets to your hand you will see that it is hot all through, but the hotness increases as you get nearer the end that was in the fire. The only explanation one can give is that the heat has travelled through the rod itself from one end to the other. This method of transferring heat is known as *conduction,* and the iron rod is said to be a *conductor* of heat.

Conduction of heat is a process by which heat is transferred from one part of the body to the other part without actual movement of the particles of the body. You shall learn more than this in this chapter later.

2. When you heat water in a kettle you place the flame under the kettle ; even in an electric kettle the heating element is at the bottom and not at the top. How, then, does the water at the top become hot ? You might say it must be by conduction, as in the case of the iron rod above, but you will see later by experiment that this is not the case. The fact is that a current, known as a *convection current,* is set up inside the water, and this carries the heat from the bottom to the top of the vessel. This method of transferring heat, about which you will learn more later, is known as *convection.*

3. When you stand in front of a hot fire or you place your hand near a flame you feel the heat and you move away. While standing in front of the fire, place a piece of cardboard between you and the fire and you will feel cold immediately, showing that the air around you and between you and the fire has not been heated, and so the heat could not have travelled by conduction. It could not have travelled by convection either, as the convection current goes up and not sideways. The heat must therefore have travelled by another method which is known as *radiation,* a way by which we receive the heat from the sun. Now let us take each method in turn.

6.3. Conduction

Try the following experiments, from which you will be able to learn several facts about the method of transferring heat by conduction.

Experiment :

To show that solids conduct heat and to compare the abilities of some substances to conduct heat (i.e., to compare the conducting powers of some substances)

Requirements :

Metal rods of equal lengths and equal thicknesses (aluminium, iron, copper, brass, zinc, lead), tripod stand, Bunsen burner, cork, tiny bits of phosphorus, heat sensitive paper, conductivity tank, candle wax.

Procedure :

(*a*) Arrange the rods on the tripod stand as shown in Fig.6.3, so that they all meet at the centre. In each case place a flat cork between the rod and the stand. Can you explain why you should do this ?

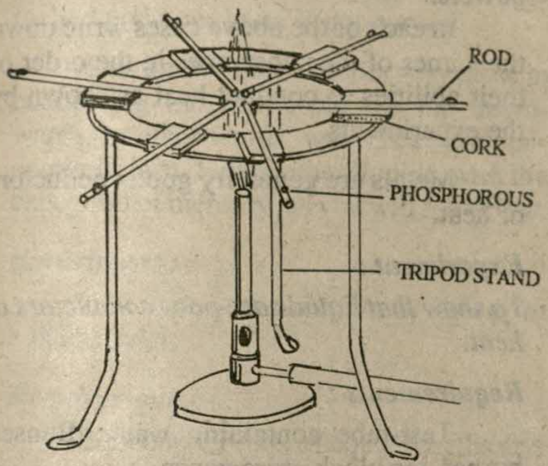


Fig. 6.3.To compare the conducting powers of metal rods.

Place tiny pieces of phosphorus in little hollows made at the free ends of the rods. Now place the flame at the meeting point of the rods. Stand back and watch what happens to the phosphorus at the ends.

You will notice that the bits of phosphorus catch fire at different times. How would you explain this ?

N.B. Phosphorus catches fire very easily even in air, and that is why it is not kept in air but under water.

(*i*) In each case heat must have travelled from the end of the rod in the fire, through the rod, to the free end. The phosphorus ignites when the heat reaches it by conduction through the rod.

(*ii*) The fact that the bits of phosphorus catch fire at different times shows that the heat does not travel at the same rate in the different rods. In other words, different substances have different abilities to conduct heat.

(*b*) Arrange the rods in the form of a fan as shown in Fig.6.4. Let about half the lengths of the rods from the free ends rest on a sheet of heat-sensitive paper. (Heat-sensitive paper is a colourless sheet of paper which has been dipped inside a special solution and dried; when it is slightly heated, the paper turns bluish-green). Place a Bunsen flame under the ends that meet as shown in the diagram. Remove the flame after heating for some time and examine the heat-sensitive paper.

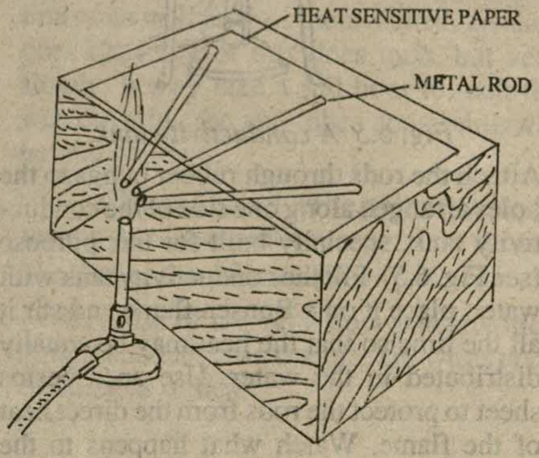


Fig. 6.4.To compare the conducting powers of metal rods using heat sensitive paper.

You will observe three bluish-green lines on the paper, along which the rods have rested. These lines will be of unequal length, provided you do not heat too long.

This again shows that in each of the rods, heat has travelled by conduction all along its length, and that the heat has travelled at different rates in the different rods.

(*c*) Melt some candle wax inside a boiling tube. Dip each rod inside it and quickly bring it out so that a thin film of candle wax is deposited all along its length.

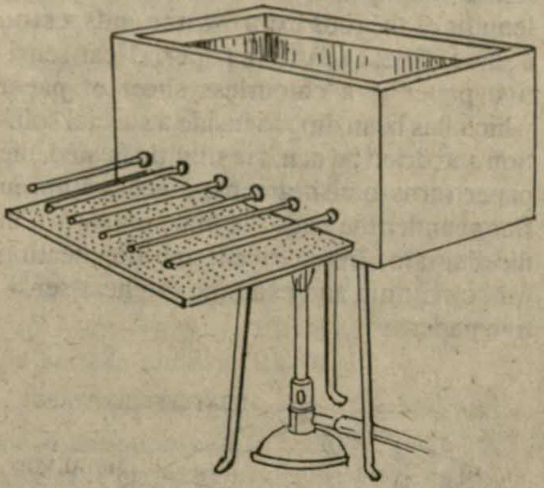


Fig. 6.5 A conductivity tank.

Attach the rods through rubber bungs to the holes arranged along one side of the conductivity tank, specially built for this purpose (see Fig. 6.5). Fill the conductivity tank with water, place it on a Bunsen flame and stir it all the time so that the heat may be equally distributed in the water. Use an asbestos sheet to protect the rods from the direct heat of the flame. Watch what happens to the rods.

In a few seconds you will notice that the layer of wax on the rods starts to melt all along the length of each rod, starting from the ends next to the tank. You also notice that in some the melting is fast and in the others very slow, but in the end the whole length of wax melts.

Here again, heat travels by conduction all along each rod, melting the wax as it travels to the other end. The heat travels at different rates in the rods, shown by the fact that the rates at which the layers of wax melt are not the same.

General conclusion :

(*a*) Solids conduct heat.

(*b*) Solids have different conducting powers.

In each of the above cases write down the names of the substances in the order of their abilities to conduct heat as shown by the experiments.

Metals are generally good conductors of heat.

Experiment :

To show that liquids are poor conductors of heat.

Requirements :

Test-tube containing water, Bunsen burner, ice block, wire gauze.

Procedure :

Put the block of ice in the water and push it to the bottom of the tube. Use a wire gauze to keep it in position there (Fig. 6.6). Now hold the test-tube in the flame of a Bunsen burner so that the top of the tube is in the flame and watch what happens.

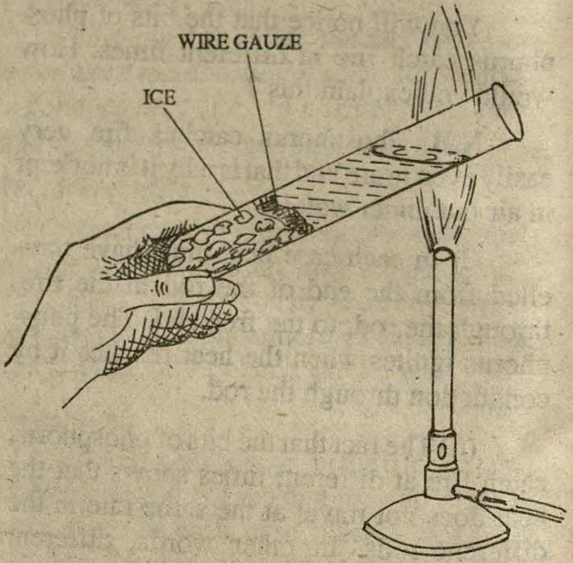


Fig. 6.6 Water is a poor conductor of heat.

You will see that the water boils at the top while the ice at the bottom has not yet melted and your hand is not burned.

This shows that water is very slow in conducting the heat from the top downwards. In other words, water is a poor conductor of heat. So are other liquids, with the exception of mercury, as you will see below.

Experiment :

To compare the abilities of liquids to conduct heat.

Requirements :

Bent copper rods of equal lengths and equal thickness, identical test-tube containing equal volumes of water, mercury, palm oil, respectively ; Bunsen burner, wooden supports for the rods, retort stand and clamp, candle wax, large asbestos sheet.

***Procedure* :**

Cover each test-tube with a thin layer of candle wax by dipping it inside molten candle wax in a boiling tube as in the previous experiment. Arrange one end of each of the bent rods to touch a liquid, equal lengths of them being in the liquids, and bring the other ends together at a point (Fig. 6.7). Support the test-tubes and the rods adequately and place a Bunsen burner below the ends meeting at a point. Use the asbestos sheet to protect the test-tubes from the direct heat of the burner. Watch what happens to the layer of wax on the test tubes.

In a few minutes you will see that the whole layer of wax on the test-tube containing mercury has melted, while only a fraction of an inch on the others melted. As time goes on, more of this does melt, but very slowly. It may take a full hour to melt the wax covering the test-tubes containing water and palm oil.

All liquids conduct heat slowly, except mercury, whose ability to conduct heat is like that of the solid metals.

Because of the very slow rate at which liquids conduct heat, they are known as *poor conductors* of heat.

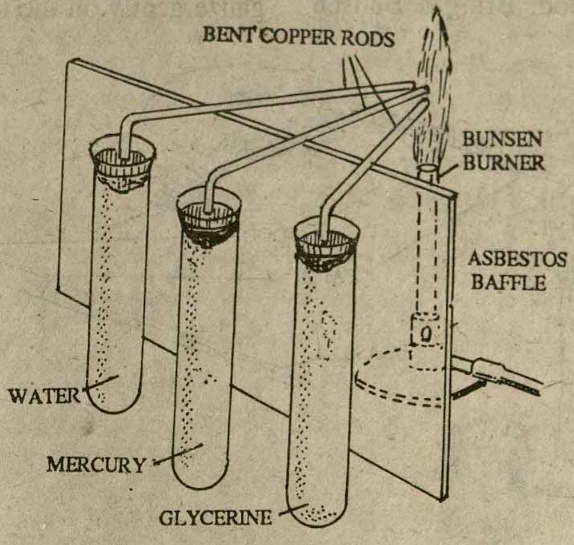


Fig. 6.7 To compare the conducting powers of liquids.

You will notice in the above experiment that the liquids have been heated from the top and not from the bottom. Can you give a reason for this ?

Conduction also takes place in *gases*, but at a much slower rate than in liquids. However, the rate of convection and radiation of heat in gases is very rapid. It is difficult to show by experiment that gases conduct heat, because it is almost impossible to get rid of the effects of convection and radiation as has been done in the case of liquids.

Now try two exciting experiments on conduction.

Experiment :

To show that wood is a poor conductor of heat.

Requirements :

A compound cylindrical bar of brass and wood, paper, Bunsen burner.

Procedure :

Wrap the paper tightly round the joint of the brass and the wood. Bring a Bunsen flame near the paper and watch what happens to the paper (Fig.6.8).

You will notice that the paper gets charred or burnt only at the section of it in contact with the wood, but that the remaining section in contact with the brass remains as if no flame has been brought near it.

Explanation :

The brass, being a good conductor of heat, conducts the heat of the flame quickly through the whole length of it and away into the air, so that no heat remains to burn the paper. But wood is a poor conductor of heat and it does not conduct the heat of the flame away, so that all the heat goes to burning the paper.

Experiment :

To study the principle of Davy's Safety Lamp.

Requirements :

Bunsen burner, metal gauze.

Procedure :

First light the burner and lower the gauze gently on the flame. Does the flame

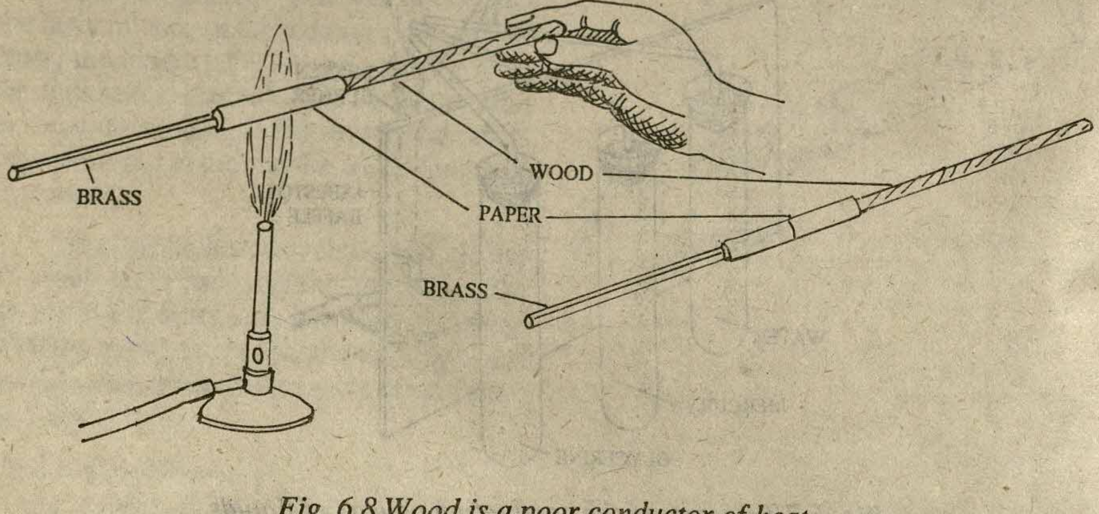


Fig. 6.8 Wood is a poor conductor of heat.

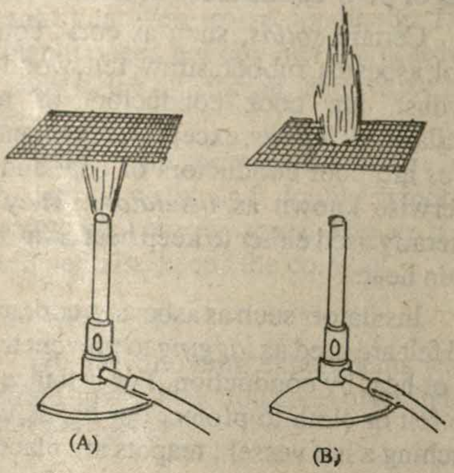


Fig. 6.9 Heat being conducted away by a wire gauze.

pass through the gauze, or does it remain below it [Fig.6.9 (*a*)] ?

Turn off the gas. Now hold the gauze over the burner, turn on the gas and light it over the gauze [Fig.6.9(*b*)]. What do you observe ? Does the flame pass down through the gauze ?

You will see, in the first case, that the flame remains below the wire gauze, while in the latter it remains above the wire gauze. In both cases, after heating for a long time the gauze gets red hot and the flame passes through.

Explanation :

The material of the gauze is a good conductor of heat and like the brass in the previous experiment, it conducts the heat of the flame away into the air, so that the little heat that escapes beyond the gauze is not sufficient to *ignite* the gas, that is, to make the gas burn. In other words, the *ignition temperature* of the gas cannot be reached. But when the gauze is red hot the heat from the gauze itself is sufficient to ignite the gas above and below it, and so the flame passes through.

Davy's Safety Lamp :

The last experiment leads us to the study of Davy's Safety Lamp or the Davy Lamp. This, one of the greatest inventions of its time, was constructed by Sir Humphry Davy, a British scientist. Before the invention of this lamp the work in coal mines was very dangerous. Explosions were common because of certain gases in the mines which would ignite and cause explosions in the presence of naked light. Davy worked hard to produce a new type of lamp that could safely be used in the mines. You should remember that these were the days before electricity. He used two facts revealed in the above experiment :

(*a*) that metals are good conductors of heat ;

(*b*) that a gas will not ignite until the ignition point is reached.

Davy tried enclosing the lamp flame in a container made of copper gauze. This he placed in a bell jar containing coal gas (Fig. 6.10). He found that even though this gas is highly *inflammable*, that is, easily ignited, it did not catch fire at all. The fact is, that the copper gauze allows the heat from the flames to spread all over it so that the amount passing through it in any direction is not sufficient to ignite the gas outside, while the gas entering the lamp burns naturally.

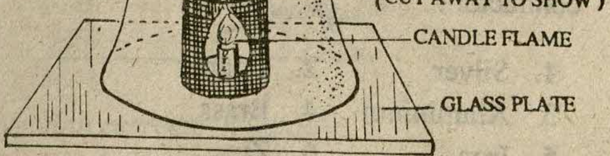


Fig.6.10 Sir Humphry Davy's experiment.

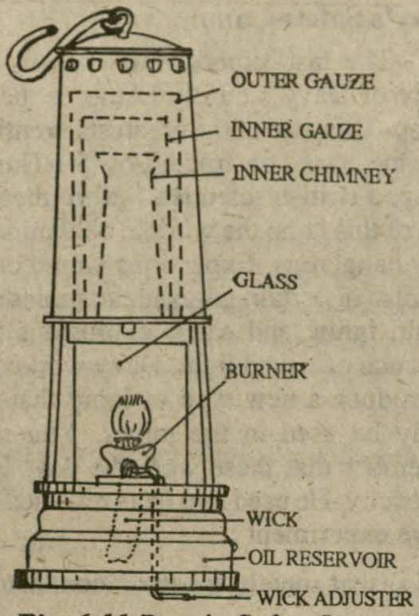


Fig. 6.11 Davy's Safety Lamp.

Thus the famous safety lamp was constructed, consisting of a light surrounded by a cylindrical wire gauze as shown in Fig. 6.11. Try to examine one very closely.

Uses of good conductors of heat :

Cooking utensils, boiler tubes and hot-water pipes, are made of metals so as to allow heat to pass through them quickly. The metals most commonly used are iron, copper and aluminium. Of these three, copper is the best conductor, but because it is expensive and quickly wears out, the other two are more commonly used. Copper, however, is used at the tips of soldering irons.

Below is a list of some of the good conductors of heat in the order of their ability to conduct heat, starting from silver, the best conductor :

1. Silver
2. Copper
3. Aluminium
4. Brass
5. Iron
6. Zinc

Uses of poor conductors of heat :

Certain *solids*, such as cork, cotton-wool, asbestos, rubber, straw, felt, wood and sawdust, are poor conductors of heat. Similarly *all liquids*, except mercury, and *all gases* are poor conductors of heat and are otherwise known as *insulators*. They are generally used either to keep heat away or to retain heat.

Insulators such as asbestos, cork, wool and felt are used as *lagging* to prevent transfer of heat by conduction. For instance, we use felt or cloth to protect our hands when touching a hot vessel ; teapots are placed in 'cosies' to prevent heat escaping from the tea ; exposed hot-water pipes are generally covered with asbestos to prevent loss of heat to the surroundings.

We use table mats made of cork, wood or felt on our dining-tables to protect the polished surface from the heat of hot plates and dishes.

The refrigerator has double walls packed with asbestos to prevent the heat of the room reaching the inside of the refrigerator.

Ice blocks are kept in sawdust to prevent the heat of the surrounding air from melting the ice.

Air, a very poor conductor of heat, improves the insulating properties of materials such as wool, felt, cork, sawdust, fur and feathers, as each of them has air trapped inside it. You can test this by putting any of them in water, and you will see bubbles of air coming out of the water. Steel and aluminium are good conductors of heat, but steel-wool and pellets of aluminium foil are bad conductors because of the many air pockets within them.

We cover ourselves with a blanket on a cold night because the blanket is made of wool which is itself a bad conductor, and which further encloses a good deal of air, making it an even worse conductor. Thus, the blanket does not conduct the heat from our body to the outside air, and we are kept warm.

In very cold countries houses are built with double walls and double windows, enclosing air between them. The air keeps heat in and also keeps the cold out.

6.4 Convection :

Try the following experiments which illustrate how convection takes place in both liquids and gases.

Experiment :

To show convection in liquids.

Requirements :

A round-bottomed flask two-thirds filled with water, potassium permanganate crystals or sawdust Bunsen burner and a long glass tube.

Procedure :

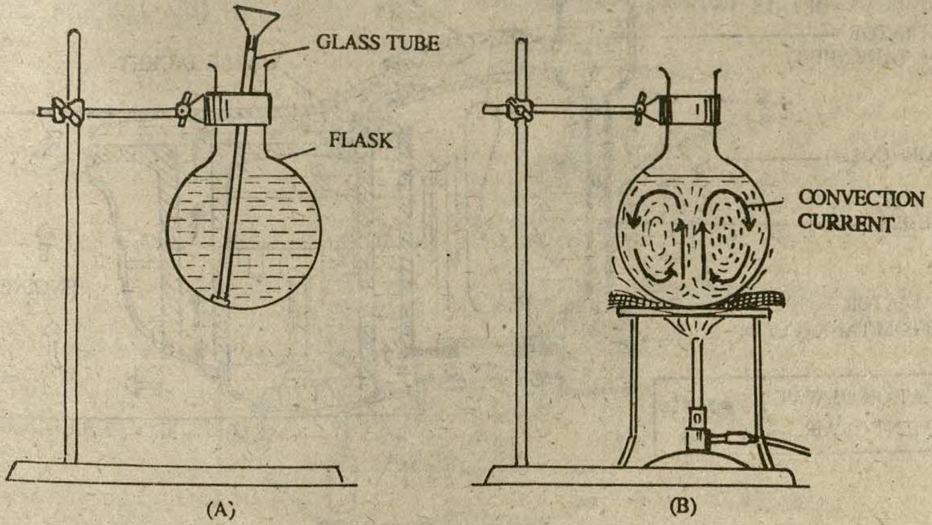
If you use sawdust, sprinkle some on the water in the flask, shake it, and some of the sawdust will settle at the bottom of the water. If you use potassium permanganate crystals pour them into the water down a narrow glass tube [Fig.6.12 (*a*)] so that the crystals go straight to the bottom of the water in the flask.

Now bring a low flame to the central part of the bottom of the flask and note what happens inside the water.

You will see the particles of sawdust rising up in the middle and coming down at the sides. In the case of the crystals, you will see streaks of violet colour rising in the middle to the surface and coming down the sides as shown in Fig.6.12 (*b*).

Explanation :

Water expands when heated, and so becomes lighter or less dense. Immediately the flame is brought near, the bottom layers of the water become warmer and lighter than the upper layers, and so are forced to rise, while the colder and heavier layers come



(A)　(B)

Fig. 6.12 To show convection currents in liquids.

down to take their place. These in turn take heat from the flame, thus becoming warmer and lighter. Meanwhile the rising layers get colder and heavier as they share their heat with the cold layers they come across while rising. The rising water now starts to fall, while the falling water rises, and so the movement continues until the water boils. These moving currents of hot and cold water are called *convection currents*, and this process of transferring heat is known as *convection.*

Motor-car radiators :

When the engine of a car is running a large amount of heat is produced in the cylinder walls and block. Unless this heat is quickly removed the engine will be damaged. Therefore it is essential to use a system of rapid cooling.

This cooling is usually produced by the car radiator (Fig.6.13). The outside of each cylinder is surrounded by a chamber called a water jacket which is connected, at the bottom, to the lower radiator tank, and, at the top, to the top radiator tank. The two tanks are connected by a series of tubes, the outside of which is 'finned' that is, made in such a way as to expose a large surface to the cold air drawn in by the fan placed near the radiator.

The explosion of the mixture of petrol vapour and air in the cylinder causes the walls of the cylinder to get hot ; this sets up convection currents in the surrounding water; the hot water passes to the top tank and then passes down the tubes in front, where it loses much of its heat to the cold air currents. It becomes cold, goes round the engine again, collecting heat from it, rises to the top tank and passes down the tubes again, giving its heat to the surrounding air. Thus the convection current continues and the engine is continuously cooled.

Experiment :

To show convection in gases.

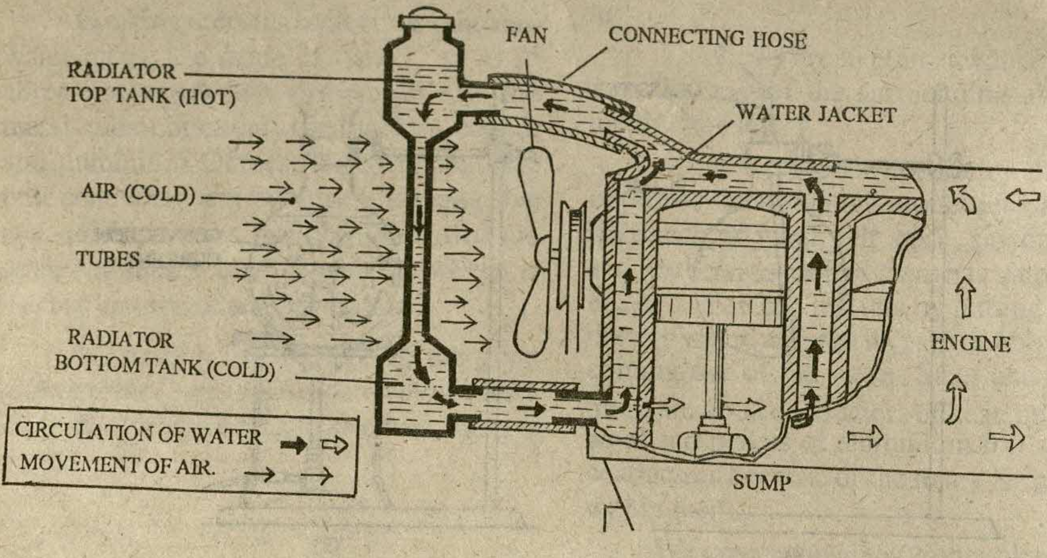


Fig. 6.13 A motor-car radiator.

Requirements :

A smoke box (that is, a rectangular box with a glass front and two metal or glass chimneys or lamp shades fixed to the top surface (See Fig.6.14), lighted candle, a piece of cloth or blotting paper, a tall, narrow cylinder open at both ends or a lamp shade, a T-piece (*i.e.*, a piece of cardboard or tin cut into the shape 'T').

Procedure :

(*a*) Place a lighted candle directly underneath one of the chimneys (A) (Fig.6.14). Now hold a smouldering cloth or paper over the other chimney (B). Watch the direction of movement of the smoke. Try the experiment with the candle under *B* and then with the candle midway between *A* and *B*.

You will see, in the first case, that the smoke passes down the chimney *B*, through the box and up the chimney *A*.

When the candle is under the chimney *B* the smoke travels in the opposite direction. But when the candle is midway between them the smoke will move in either direction.

Explanation :

The air above the candle is heated and so becomes lighter. It, therefore, rises up the chimney immediately above it. Cooled air comes down through the other chimney to take its place, and so the air is set into circulation. The smoke from the smouldering piece of cloth mixes with the cold air coming down the chimney and shows the direction of the current of air (Fig.6.14).

When the candle is midway between the chimneys, the direction of the current depends on which air gets heated first, and so depends on change.

(*b*) Light a candle and stand it on some soft felt or in water. Lower the narrow cylinder or lamp shade over the candle. If you use felt, press the shade tightly on the felt to make the lower end of the shade air-tight. Watch what happens to the candle flame [Fig.6.15 (*a*)].

Light the candle again and place the shade over it as before, but now, while the flame is dying off quickly lower the T-piece into position as shown in Fig.6.15 (*b*). Watch the candle flame. Place a smouldering cloth in position as shown and see how the smoke moves.

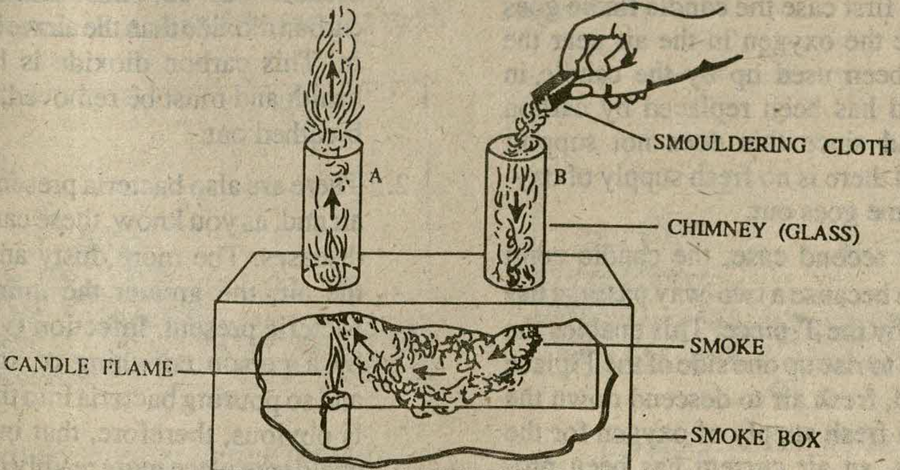


Fig. 6.14 To show convection in gases using a glass chimney.

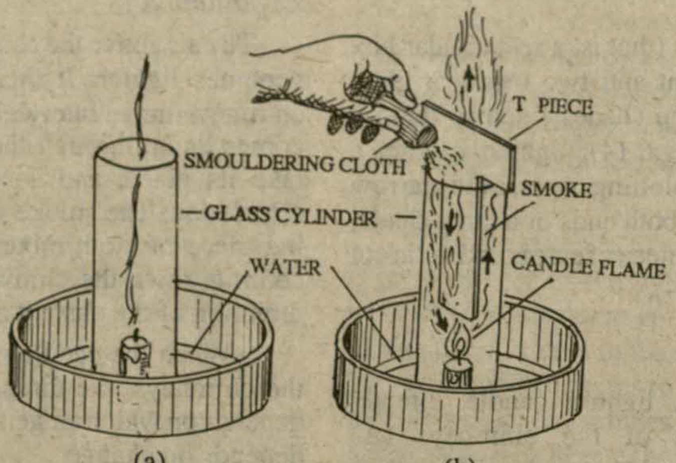


Fig. 6.15 To show convection in gases using a glass cylinder and a T-piece.

You will notice that in the first case the candle goes out after a few seconds. In the second case when the T-piece is lowered into position the flame, which is already showing signs of going out, suddenly glows again and continues burning until the T-piece is removed, when it dies out. You will also note that the smoke moves down one side of the T-piece and rises up the other side.

***Explanation* :**

In the first case the candle flame goes out because the oxygen in the air near the flame has been used up by the candle in burning and has been replaced by carbon dioxide, and since this does not support burning and there is no fresh supply of oxygen, the flame goes out.

In the second case, the candle continues to burn because a two-way passage has been made by the T-piece. This enables the hot used gas to rise up one side of the T-piece and the cold, fresh air to descend down the other with a fresh supply of oxygen for the flame. Thus, an air current has been produced and the smoke from the smouldering piece of cloth shows its direction.

We can now say generally that convection currents exist in gases just as in liquids.

***Ventilation* :**

A room is said to be well-ventilated when the air in it is fresh and pure. Good ventilation is necessary in a house for the following reasons :

1. Good ventilation prevents respiratory and other diseases. The air we breathe out contains much more carbon dioxide than the air we breathe in. This carbon dioxide is bad for health and must be removed, as it is breathed out.
2. There are also bacteria present in the air and, as you know, these can cause diseases. The more dusty and dirty the air, the greater the number of bacteria present. Infection is caused by a person coughing or sneezing and so pouring bacteria into the air. It is obvious, therefore, that infection could take place more readily in badly ventilated rooms and in crowded buses and trains.

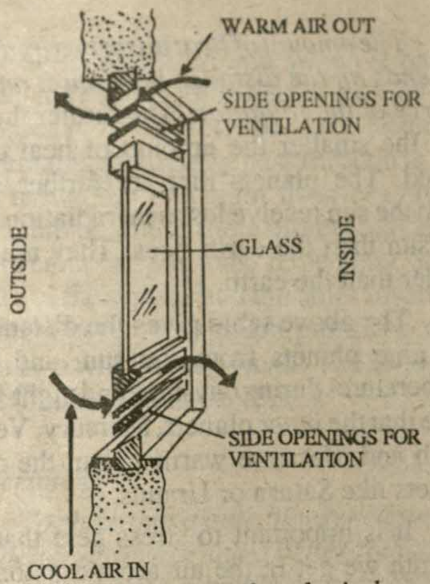


Fig.6.16 A ventilated window.

3. Breathing into the air also increases the amount of water vapour in the air, and too much of this in the air makes one feel uncomfortable.

The main purpose of ventilation, therefore, is to supply plenty of fresh air in order to prevent an accumulation of carbon dioxide, moisture and bacteria. Any windows in a room produce this effect, and so are very useful in ventilation. Fig. 6.16 shows a ventilated window which allows warm air in a room to escape and cold fresh air to come in at the bottom. It is one of the modern methods of ventilating rooms in hot countries.

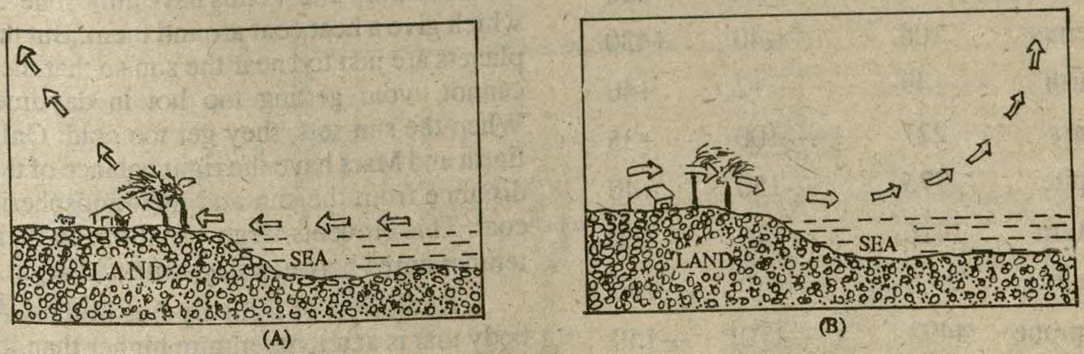
Land and sea breezes :

During the day the land gets hot more quickly than the sea, while at night the land cools more rapidly than the sea. As a result of this, during the day the air immediately above the land becomes hotter and rises, while cool air blows in from the sea to take its place. This circulation of air gives rise to a convection current known as a *sea breeze* [Fig.6.17 (*a*)].

At night time the air above the sea is warmer than that above the land, so it rises and the cool *land breeze* blows gently from the land towards the sea [Fig.6.17] (*b*).

Winds :

These are examples of natural convection currents on a large scale. The *Trade Winds*, for example, are caused by hot air in the equatorial districts rising and the colder air flowing in from the North and South to take its place. On account of the rotation of the earth on its axis, these winds are deflected, that is, turned away from their original North-South directions, and they become North-East and South-East trade winds respectively.



(a) Sea breezes during the day. *(b) Land breezes at night.*

Fig. 6.17 Convection currents.

6.5 Radiation :

How does the sun's heat reach the earth? You have heard that the sun is the real source of all heat on the earth because the various forms of fuel—coal, wood and gas—are substances which depended originally on plant life, and, as you know, plants make use of the sun for their growth. The question now is : how does the heat of the sun reach the earth ? It is now known that it travels by *radiation,* that is, it travels to the earth without heating the air through which it passes. It is very easy to show this. In bright sunshine we receive a large amount of heat ; if, however, a cloud suddenly covers the sun we feel the fall in temperature immediately. If the air surrounding us had been heated by the sun's heat we would not have felt this immediate fall in temperature.

Table

Distance of the planets from the sun and their average temperature.

Planet	Distance from Sun in Million Kilometres	Average Temperature in Degrees Celsius	
		Night	Day
Mercury	58	—260	+410
Venus	108	—40	+450
Earth	149	+2	+40
Mars	227	—100	+35
Jupiter	775	—150	+40
Saturn	1416	—170	+50
Uranus	2866	—170	—150
Neptune	4493	—170	—150
Pluto	5904	—170	—150

The amount of heat absorbed by a body depends on the distance between it and the source of the radiation. The farther the two are, the smaller the amount of heat transferred. The planets that are farther away from the sun receive less heat radiation from the sun than the earth does. They are thus colder than the earth.

The above table gives the distance of the nine planets from the sun, and their temperatures during day-time and night-time. Note that the *inner* planets, Mercury, Venus, Earth and Mars are warmer than the outer planets like Saturn or Uranus.

It is important to stress here that the warmth we get in the air around us on the earth is not due to the direct heat from the sun. What happens is that when the radiant heat from the sun falls on the earth some of it is absorbed by it and makes it warm. The warm earth then gives out some of its heat to the air in contact with it, and the air gets heated by convection. It is this air that surrounds us.

Thus the temperature variations in the day-time and night-time of each planet depends on the atmosphere around the planet. Uranus, Neptune and Pluto have no atmosphere around them and they are very far from the sun and hence they are very cold all the time. Mercury and Venus have atmospheres which give a heat coat around them. But the planets are just too near the sun so that they cannot avoid getting too hot in daytime. When the sun sets, they get too cold. Only Earth and Mars have the right balance of the distance from the sun and the atmospheric coat. This prevents large variations in their temperatures between day-time and night.

Radiation of light by hot bodies. A body that is at a temperature higher than its surroundings radiates heat (*i.e.*, sends out heat) in all directions. This radiant heat, like light, travels in a straight line and does not heat the medium through which it passes. When it falls on an object a part of it is absorbed by the object, a part is reflected and the remaining part may pass through it. You will remember that light does exactly the same things. These three effects may occur in different proportions, depending on the nature of the surface and the object itself, but if one effect is very much pronounced the other two will be very small. The following experiments will show this :

Experiment :

To show that a dull, blackened surface is a better absorber and a better radiator of radiant heat than a bright or polished surface.

Requirements :

Two small tins of the same size with the lids soldered on, cork to fit holes made in the lids, two thermometers, Bunsen burner, two supports for the tins, cork or asbestos sheet.

Procedure :

Polish one of the tins very well and blacken the other completely by covering it with soot ; this you can do conveniently by holding the tin in a candle flame. Fix each tin with a thermometer and arrange the apparatus as shown in Fig.6.18 taking care to see that the Bunsen flame is exactly midway between the two surfaces (this is not easy to arrange) and that the sides of the tins are at the same level as the flame. Now record the temperature at one-minute intervals. After about ten to fifteen minutes, remove the flame and allow the two tins to cool down, recording the temperatures again at one-minute intervals.

Time in Minutes	Temperature inside the blackened tin (°C)	Temperature inside the polished in (°C)

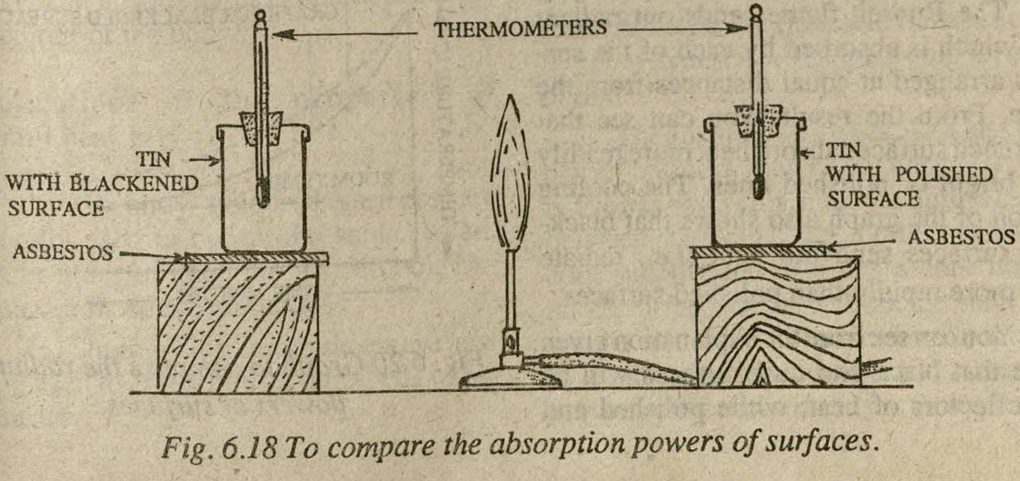


Fig. 6.18 To compare the absorption powers of surfaces.

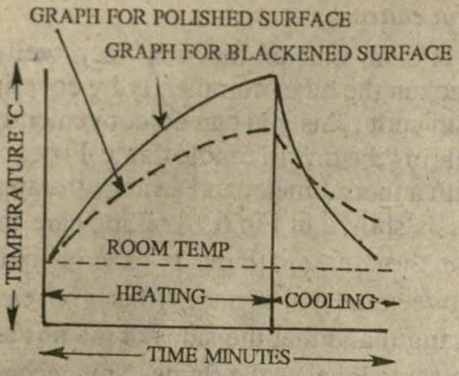


Fig. 6.19 Graph to show the absorption and radiating powers of different surface.

Now plot a graph to show these results (Fig. 6.19).

The experiment can also be performed by simply suspending two identical thermometers at equal distances from the Bunsen flame. The bulb of one of the thermometers should be blackened with soot or painted black, while the other is left as it is. The temperatures are again taken at one-minute intervals and graphs drawn.

The graphs in Fig. 6.19 illustrate that the temperature inside the blackened tin rises more rapidly than that inside the polished tin, and also falls more rapidly.

Explanation :

The Bunsen flame sends out radiant heat which is absorbed by each of the surfaces arranged at equal distances from the flame. From the results you can see that blackened surfaces absorb heat more readily than bright or polished ones. The cooling portion of the graph also shows that blackened surfaces send out heat (*i.e.,* radiate heat) more rapidly than polished surfaces.

You can see from the explanation given above that black and dull surfaces will be bad reflectors of heat, while polished and white surfaces are good reflectors. Thus, a good absorber is a bad reflector of radiant heat, and *vice versa*. Compare this with the behaviour of light.

Experiment :

To show that a black surface is a better radiator of heat than a polished one.

N.B. The second part of the above experiment has shown this, but it can be shown more clearly by this experiment.

Requirements :

Same as for the last experiment, but, in addition, beaker containing water.

Procedure :

Boil some water in a beaker. Pour some of this into the polished tin to fill it about three-quarters full. Replace the lid which is carrying a thermometer and place the tin on an asbestos sheet. Read and record the temperature first at half-minute intervals and later at one-minute intervals, until the water has cooled almost to room temperature. Now repeat the experiment with the blackened

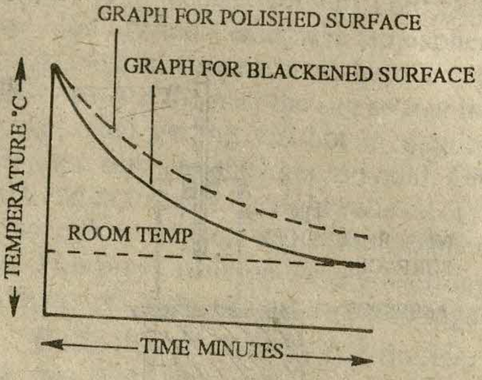


Fig. 6.20 Graph to compare the radiating powers of surfaces.

tin, taking care to fill the tin with the same quantity of water as used in the first case. The starting temperature should be about the same. Record your readings as shown in the previous experiment. Also draw a graph of temperature against time.

The graphs obtained will show that the temperature of water in the blackened tin falls more rapidly than that of the polished tin (Fig. 6.20).

Explanation :

Both surfaces are losing heat to the surrounding air by radiation. The result shows that the blackened surface radiates heat at a faster rate than the polished surface, that is, it is a better radiator of heat.

In the two experiments above, by using paints it is possible to compare the absorption and the radiating powers of any type of surface.

It can now be stated that a black, dull surface is a good absorber, a good radiator, but a bad reflector of radiant heat, and that a polished, bright surface is a bad absorber, a bad radiator, but a good reflector of radiant heat. To put it more generally, good radiators are good absorbers, but bad reflectors; while bad radiators are bad absorbers but good reflectors. Also the amount of heat that a body can absorb by radiation depends on the colour of the body.

Applications of the properties of radiant heat :

1. Brightly coloured surfaces are generally used to reflect the sun's radiant heat in order to keep the inside cool. Examples of these are numerous :

(*a*) Shining aluminium sheets are now being used to cover houses and sheds in hot countries.

(*b*) Tanks holding water for domestic purposes are generally painted with aluminium paint.

(*c*) Light-coloured dresses are generally worn in hot countries.

(d) The fireman polishes his brass helmet.

2. Some vessels containing hot substances are generally polished or painted brightly to prevent heat loss by radiation. Examples are many :

(*a*) Tea-pots are often silver, silver-coated, or highly polished.

(*b*) Boilers and pipes carrying hot water in factories and boiler houses are brightly painted.

3. Travellers in the desert find that, while the days are unbearably hot, the nights are unbearably cold. This is because during the day the rough sand, being a good absorber of heat, readily absorbs the radiant heat from the sun and becomes very hot; but during the night it readily radiates the heat, and so becomes very cold, a good absorber being a good radiator.

The vacuum or thermos flask :

In this apparatus (Fig.6.21) heat transference is reduced to a minimum. Its chief aim is to prevent heat loss to, or heat absorption from, its surroundings so that any hot material inside the flask will remain hot and any cold material will remain cold for a long period of time.

The apparatus consists of a glass bottle placed inside a metal container. The glass bottle has two walls and a vacuum is created between the walls. The bottle stands on a cork support and also has a cork lid. The inside surfaces of the walls of the glass bottle are silvered. It is easy to see how loss of heat by conduction, convection and radiation is prevented by these means.

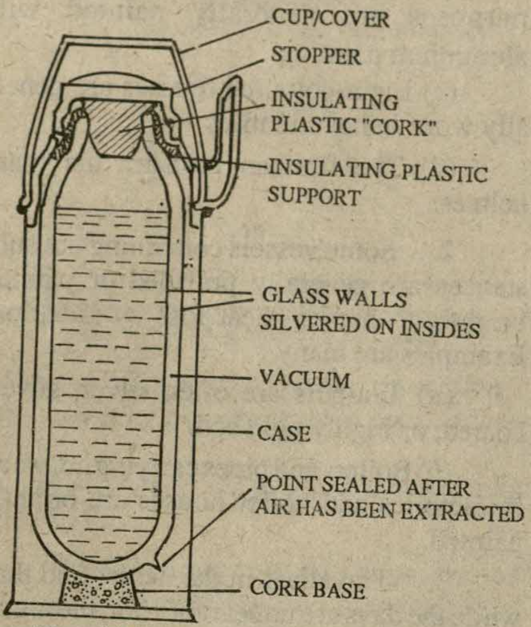

CUP/COVER
STOPPER
INSULATING PLASTIC "CORK"
INSULATING PLASTIC SUPPORT
GLASS WALLS SILVERED ON INSIDES
VACUUM
CASE
POINT SEALED AFTER AIR HAS BEEN EXTRACTED
CORK BASE

Fig. 6.21 Section of a vacuum flask.

(*a*) *By conduction :* The presence of a vacuum in the double walls, the cork support and the cork lid—all prevent the loss of heat by conduction. Cork is a poor conductor and a vacuum is a non-conductor, of heat.

(*b*) *By convection* : The presence of a vacuum again makes loss of heat by convection impossible as there is no material substance to convey the heat.

(*c*) *By radiation* : The inside surfaces of the walls of the glass bottle are polished. While the polished outer surface of the inner wall prevents loss of heat by radiation in the same way as a silver tea-pot, the polished inner surface of the outer wall reflects back to the inner wall whatever heat escapes to it.

It appears from the above consideration that it is practically impossible for heat to escape at all from the flask, but when one remembers that the cork is still a conductor, though a poor one, and that the vacuum cannot be a perfect vacuum, and so convection might still take place, one would understand why some heat does escape and the hot contents become cold after a considerably long time.

Summary

1. Transfer of heat between two bodies takes place till their temperatures become equal.
2. There are three distinct processes by which transfer of heat may take place — *conduction*, *convection* and *radiation*.
3. *Conduction* is a process by which heat is transferred from one part of the body to the other part without actual movement of the particles of the body.

   Heat travels chiefly by this method in solids.
4. Different substances conduct heat to different extents. Substances which conduct heat rapidly are known as good conductors. Others are called bad or poor conductors or *insulators*. Copper, aluminium, iron, brass are examples of good conductors. Cork, asbestos, felt, sawdust are examples of insulators.

   Liquids (except mercury) and gases are all bad conductors.

   Vacuum is a non-conductor.
5. Both good and bad conductors have their uses in everyday life. Davy's Safety Lamp is a very important application of good conductor.
6. *Convection* is a process by which heat is transferred from one place to another by the hot body itself by the actual movement of the particles.

Convection occurs mainly in liquids and gases.

7. The process of convection in liquids is used to cool the engines of the motorcars ; convection in gases is used in ventilation and is the cause of land and sea breezes and the trade winds.

8. *Radiation* is the process by which heat flows from one place to another *without heating* the medium between them. The sun's heat reaches the earth by radiation.

9. Good absorbers of radiant heat are bad radiators and bad reflectors.

   This fact explains the use of polished tea-pots, bright clothes and aluminium sheets and paints in hot countries.

10. A thermos flask is an example of a useful device in which the normal conduction, convection and radiation of heat are greatly reduced.

Questions

(A) Objective Type Questions :

1. Fill in the blanks with suitable words :

(*i*) Air is a very.................

(*ii*) All metals readily.................heat whereas gases and liquids are............... with the exception of........................which is a good conductor.

(*iii*) We get heat from the sun by means of ....

(*iv*) In convection, heat travels.......................the movement of the particles.

(*v*) In conduction, heat travels..........................the movement of the particles.

(*vi*) Air and water are heated by...

(*vii*) In convection, water travels from....................region to the ....region.

2. Rearrange the items of Column B so that each one is on the same line with that in Column A which is most closely related to it.

Column A	Column B
(*a*) Sun cooker	(*a*) keeps hot things hot and cold things cold.
(*b*) Black bodies	(*b*) are caused by convection.
(*c*) Trade winds	(*c*) receives heat by radiation.
(*d*) Thermos flask	(*d*) is based upon conduction of heat.
(*e*) Davy's Safety Lamp	(*e*) are good absorbers of heat.

3. State whether the following statements are true (T) or false (F) :

(*i*) A black, dull surface is a good reflector of radiant heat.

(*ii*) Cotton-wool and rubber are poor conductors of heat.

(*iii*) All solids have the same conducting powers.

(*iv*) Conduction also takes place in gases, but at a much slower rate than in liquids.

(*v*) Ice blocks are kept in sawdust to prevent the heat of the surrounding air from melting the ice.

(*vi*) Convection takes place in both solids and liquids.

(*vii*) Bad conductors do not have their uses at all in everyday life.

(B) Very Short Answer Type Questions :

1. Name the processes by which transfer of heat takes place.
2. Do solids have different conducting powers ?
3. Give four examples of good conductors of heat.
4. Give four examples of bad conductors of heat.
5. Which process (or processes) takes (or take) place in gases : Conduction ; Convection ; Radiation ?
6. Cooking utensils are made of metals, the metals most commonly used are iron, copper and aluminium. Of these three which is the best conductor ?
7. A cold spoon is dipped in a hot cup of tea. By which process does the spoon absorb heat from the tea ?

(C) Short Answer Type and Essay Type Questions :

1. Why is the handle of a kettle for boiling water usually covered with thin cane strips ?
2. How do woollen clothes keep us warm in winter ?
3. On a cold winter day, why do we feel colder when the sky is clear than when it is cloudy ?
4. How does a thermos flask help to keep a warm liquid warm, and a cold liquid cold ?
5. What causes the draught up a chimney ?
6. Explain why, in the electric kettle, the heating element is placed at the bottom and not at the top of the kettle ? Why is the handle of electric kettle made of ebonite or wood ?
7. Usually ice is covered with saw dust. Explain the reason.
8. Explain why people prefer using white or light coloured clothes in summer ?
9. At low temperatures, why do metallic objects, when touched, appear to be colder than wooden objects ?
10. (*a*) Name the various modes of transference of heat. What are the conditions needed for the conduction of heat ?

    (*b*) Distinguish between :

    (*i*) Good and poor conductors.

    (*ii*) Good and bad absorbers.

    Give three examples of each in (*i*) and (*ii*).

11. Pick out the good and bad conductors of heat from the following list :

    Brass, card board, ebonite, glass, iron, brick, straw, mercury, air, silver, copper, wood, leather, wool.

12. Draw and label a Davy Safety Lamp. Describe an experiment to show how it works.
13. A good absorber is a good radiator. How can you show this by experiment ?
14. Describe one experiment to show convection in a liquid and one experiment to show convection in gases.
15. Describe an experiment to show that different solids conduct heat at different rates and one to show that a liquid is a poor conductor of heat.
16. Why is sunlight hot while moonlight is "cool" ?
17. When cold milk is added to hot tea, how does the heat transfer take place ?
18. Why does sugar dissolve faster in hot milk than in cold milk ?
19. Give the reasons for the occurrence of storms.

□ □

CHAPTER 7

LIGHT

7.1 In ancient times man depended on the light of the sun by day and the moon and the stars by night. It was a great step forward when the first caveman pulled a glowing stick from his fire and carried it to light his cave.

In a dark room you cannot see anything even though you keep your eyes open. As soon as you switch on a lamp, objects in the room become visible. Thus, *you can see things only in the presence of the light*. Also, you cannot see with your eyes closed, even if the source of light is present. The eyes have the special property of sight.

For vision you need a source of light as well as your eyes. *A source of light spreads light in all directions.*

7.2 Sources of Light :

An object that gives out light is called source of light. Our chief source of light energy is the sun. It is believed that the energy of the sun is atomic energy. If it were not for the light we get from the sun, life on the earth would not be possible. Light enables a green plant to perform the miracle of photosynthesis, the amazing chemical change by which it combines carbondioxide, water and sunlight into starch and oxygen. Sun is the *natural* source of light. Stars are other natural light sources. Some of them are even brighter than the sun. But they are so far away from us that they are seen at night only as twinkling points in the sky. The glow-worm or the fire-fly (*jugnu*) is another natural source of light.

A large number of artificial (man-made) sources of light are also in use *viz*., fire, oil lamps, candles, the torch, gas lamps and electric bulbs etc. In these sources of light, the light is given out by flame or heated filaments. Many light sources give out heat as well. The sun and stars are sources of both heat and light. An electric bulb heats up as it glows.

Such objects which give off their own light are called LUMINOUS objects.

There are also non-luminous objects which do not produce any light. Most of the objects are non-luminous. The walls, the trees, the bench and even human bodies are non-luminous. They are visible only because of light energy which falls on them from other luminous objects, which they reflect to our eyes. *Earthlight* is the light of the sun reflected from the surface of the earth. The astronauts who went to the moon did see earthlight there. Different parts of the object reflect differently, thus defining the shape and size of the object. The moon, for example, can only be seen by the light energy that falls on it from the sun (Fig.7.1).

Not only does the moon revolve round the earth, it also revolves round the sun, along with the earth (Fig 7.1).

In position 1, the sun's rays fall directly on the moon and we see moon as a full disc of light. We call this the *full moon*. As it moves round the earth we can only see that part of the moon that is lighted up by the sun and is towards us. Thus, in position 2, we see the moon not as a full disc but as a *crescent*. In position 3, the part of the moon facing the earth is dark. It is not lit by the sun. It is the other part that is facing away from us which is now lit. We now have the new moon in position 3. During the positions 1, 2 and 3 the moon wanes *i.e.*, the bright portion of the moon becomes smaller and smaller as it moves from1 to 3. Between positions 3 and 1, it is in the waxing phase *i.e.*, the bright position of the moon increases. Thus we have *purnima* (position 1) waning in two weeks into the *amavasya* (position 3) which again grows during the fortnight into *purnima*.

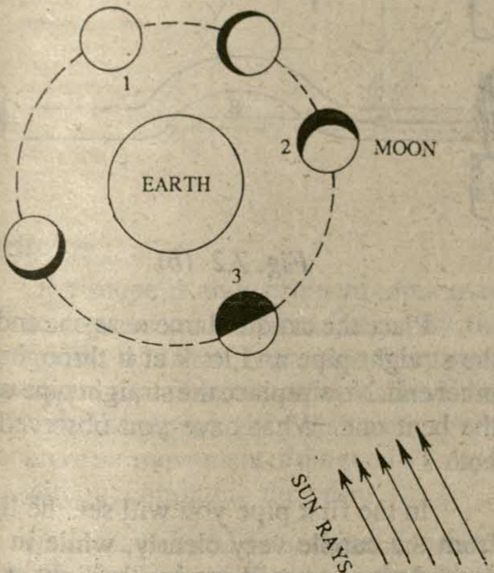


Fig. 7.1

Some non-luminous bodies can be made luminous. A piece of charcoal is non-luminous but when it burns, it gains luminosity.

Some light sources are hot and others cold.

In an electric bulb the filament is cold and non-luminous. But as soon as you turn on the switch, electric current flows through the filament and it becomes very hot and luminous. It is said to be incandescent. The sun is literally a burning globe and hence a hot source of light.

There are some *cold* sources of light *e.g.*, fluorescent tubes, neon bulbs etc., as they remain quite cool when they give out light on passing current through them. Firefly is also a cold light source.

Some sources of light are brighter than others. A firefly is a very feeble source of light. A candle is brighter than the firefly. An electric bulb is far brighter than the candle. The *brightness* (or the *luminous intensity*) of a light source is measured in comparison to the brightness of a candle in units called the *candle power*. The modern internationally accepted unit of brightness of a source is the *lumen*.

1 lumen = 12.56 candle power

The brightness at a given surface is measured in units of *lumen per unit area* called *footcandles*. The modern unit is the *lux*.

1 foot candle = 10.76 lux.

7.3 Transparent and Opaque Bodies :

Substances through which light can pass are called *transparent*. Air, clean water, plastics, glass are transparent bodies.

Substances which allow only part of light to pass through are called *translucent*. Ground glass, oil paper, thin polythene sheets are called translucent.

Substances which do not allow the light to pass through them are called *opaque*. Wood, metal, brick, book, etc., are examples of opaque bodies.

Activity

Find out through which of the following substances you are able to see the source of light. List these substances as opaque, transparent and translucent in the following table :

A sheet of glass, water, polythene sheet, wood, steel plate, glycerine, kerosene oil, book, greased paper, grounded sheet of glass.

Opaque	Transparent	Translucent

7.4 Light Travels in Straight Lines :

The light coming out of your torch, the headlight of a car and sun light, entering a dark room through the hole of a window, all follow a straight path.

Generally, sunlight entering a room through a slit is not visible, but if a dusty cloth is shaken or if the room is filled with smoke, the path of the light becomes visible.

Activity :

Take a wooden box of suitable size. Fit a transparent glass plate on the top of the box. One of the shorter side faces of the box is open. Cover this side with a sheet of black paper.

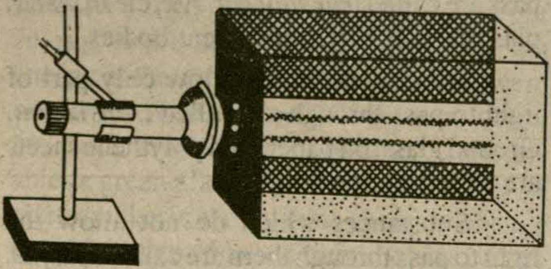


Fig. 7.2 (a) Light travels in a straight line

Fill the box with smoke. Make a few pin-holes on the black paper pasted on the shorter side. Hold a torch in front of the holes and look through the glass on top of the box. Observe that the light rays made visible by smoke appear in straight lines. For better results, perform the experiment in a dark or semi-dark room.

Activity :

To show that light travels in a straight line ; take two pipes (metal or carboard), one straight and the other bent as shown in Fig. [7.2 (*b*)] and a candle flame.

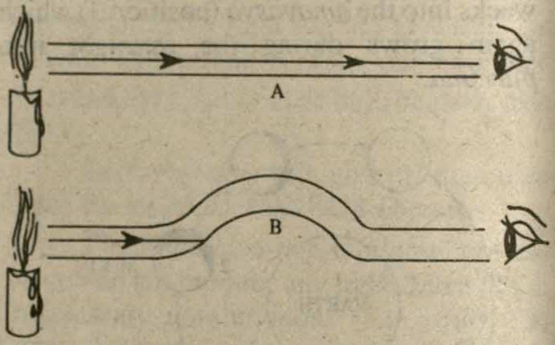


Fig. 7.2 (b)

Place the candle flame near one end of the straight pipe and look at it through the other end. Now replace the straight pipe with the bent one. What have you observed in both ?

In the first pipe you will see the light from the candle very clearly, while in the second pipe you will not see the light at all. This is because light can only travel in a straight line.

Activity :

Take two pieces of cardboard, each having a pin-hole at its centre and arrange them vertically one behind the other, in such a way that the two holes are exactly at the same level with each other. Now if a candle is placed behind and in level with the hole of the second cardboard, it can be seen when viewed through the hole of the first cardboard. But when one of the cardboards is displaced a little to one side or the other, the candle is no longer visible. This shows that light travels in straight lines.

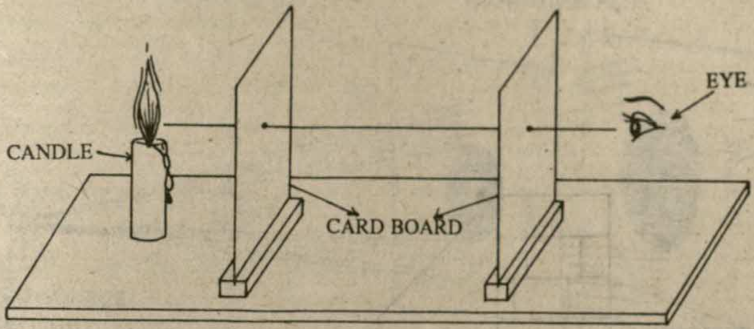


Fig. 7.2 (c)

Periscope :

Periscope is an instrument often used by the captain of a submarine or by the commander of a tank. It enables the submarine captain to observe objects above the surface of the water and the tank commander to observe the movement of the enemy around him without coming in the open.

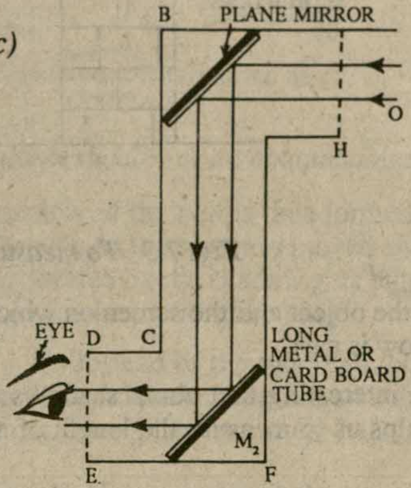
A short statured person can also use a periscope for looking above the crowd barriers or around corners.

It works on the principle that light travels in a straight line.

A periscope is made by taking a long metal or cardboard tube bent twice at right angles.

Two plane mirrors are fixed at the two bends of the tube parallel to each other and inclined exactly at 45° to the axis of the tube.

When an object is situated in front of the upper mirror, its image, after reflection from the two mirrors, is seen by the eye kept close to the lower mirror. The eye is thus able to see objects that are well above its level and are so obstructed that they cannot be seen directly.



Periscope Fig. 7.2 (d)

7.5 Shadows :

Shadow is a dark space behind an opaque object when it is placed in the path of light. It is a well-known fact that opaque objects cast shadows. When you walk in the sun, the shadow cast by your body moves along with you. The size of your shadow depends on the time of the day. In the early morning or in the afternoon, your shadow looks very long, while at noon the shadow is very small. This is because the sun is directly overhead.

Size of a shadow cast by an object depends on the relative positions of the source

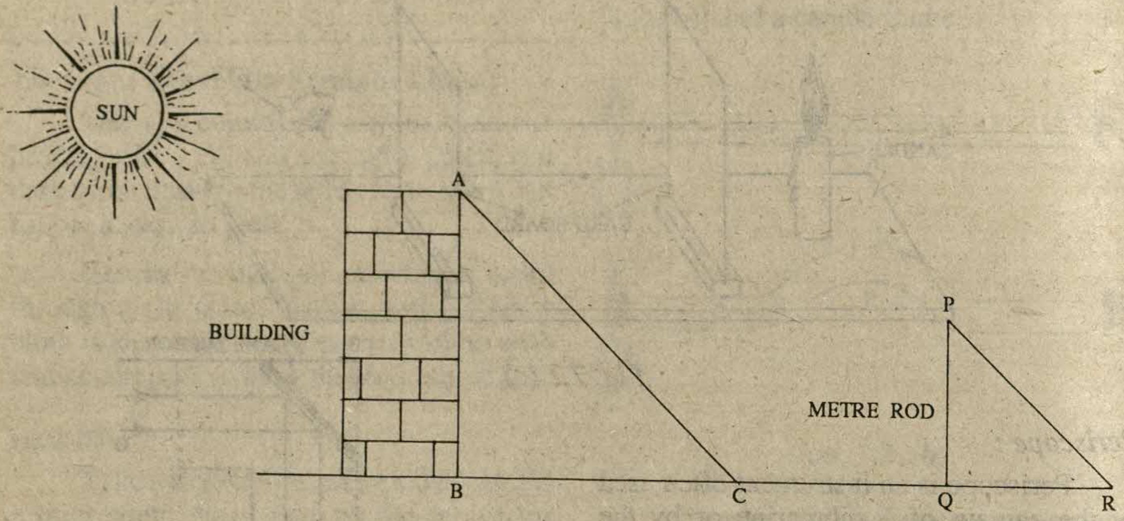


Fig. 7.3 To measure the height of a building

of light, the object and the screen on which the shadow is cast.

An interesting fact about shadows is that it helps us to measure the length of an object.

For example by measuring the length of the shadow formed by a tall building in sunlight we can calculate its height without having to climb it. In Fig 7.3 PQ is a metre rod and AB is the height of a tall building that we want to find out. QR is the shadow of the metre rod and BC is the shadow of the tall building. Since Δ^s ABC and PQR are similar,

therefore, $\frac{AB}{BC} = \frac{PQ}{QR}$

$$\text{or } AB = \frac{PQ}{QR} \times BC = \frac{BC}{QR} \times 1 \text{ metre}$$

$(\therefore PQ = 1 \text{ metre})$

Shadows BC and QR can be measured with a measuring tape or metre-stick.

Hence the height AB of the tall building can be measured.

Similarly we can measure the height of a tree without climbing it.

7.6 Variation of the size of a shadow with the size of source of light

You may wish to try the following activities :

Activity :

(*a*) Place a ball in the path of light from a torchlight from which the glass shade covering it has been removed. Let the room be darkened and put a white screen behind the ball. What do you notice on the screen ? Move the screen gradually away from the ball and note what happens.

On the white screen you will see a *uniformly thick shadow* of the ball, having the same shape as the ball and getting bigger and bigger as the screen is moved away from the ball.

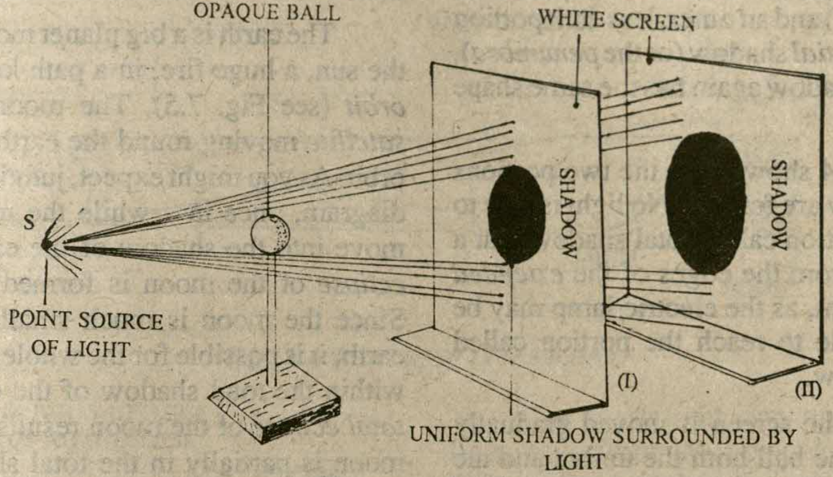


Fig.7.3(a) A point source of light forms a uniform shadow of an opaque object.

Explanation :

Fig. 7.3(*a*) shows how the shadow is formed : The torchlight bulb *S* (generally called a *point source* of light) sends out light in all directions, but the portion of the light that strikes the ball is not let through by the opaque ball, and so cannot reach the screen. A shadow of the ball is thus formed on the screen (*i*). As the screen is moved away, the area covered by the shadow gets bigger and bigger as shown on screen (*ii*).

(*b*) Instead of the torchlight bulb, use an ordinary electric lamp and switch on the current. Now place the same ball between

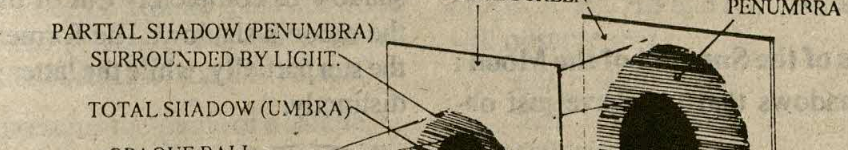


Fig. 7.4 Formation of a shadow by an extended source of light.

the lamp and the screen and note what the shadow is like. It now consists of two parts: a dark, inner portion called the *total shadow* (or the *umbra*) and an outer, less dark portion called the *partial* shadow (or the *penumbra*). The whole shadow again has the same shape as the ball.

Fig. 7.4 shows how the two portions of the shadow are formed. No light is able to reach the portion called total shadow, but a bit of light from the edges of the *extended source* of light, as the electric lamp may be called, is able to reach the portion called partial shadow.

When the screen is moved gradually away from the ball both the umbra and the penumbra increase in size [screen (*ii*)]. This happens when, as shown in the diagram (Fig. 7.4), the source of light is smaller than the ball. Now try a smaller ball or a piece of chalk. You will see the same type of shadow, a darker portion surrounded by a less dark portion, but as the screen is moved gradually away, while the penumbra gets bigger and bigger, the umbra gets smaller and smaller until it vanishes completely and is later replaced by light.

Try to draw a diagram to show how this happens.

7.7 Eclipses of the Sun and of the Moon :

The shadows that you have just observed in a dark room occur on a much larger scale among the heavenly bodies, and they produce what are known as eclipses.

The earth is a big planet moving round the sun, a huge fire, in a path known as its *orbit* (see Fig. 7.5). The moon, too, is a *satellite* moving round the earth in its own orbit. As you might expect, judging from the diagram, once in a while the moon might move into the shadow of the earth and an *eclipse* of the moon is formed (Fig. 7.6). Since the moon is much smaller than the earth, it is possible for the whole moon to be within the total shadow of the earth and a *total eclipse* of the moon results. When the moon is partially in the total shadow, and partially in the partial shadow of the earth, a *partial eclipse* of the moon results.

Again, once in a while, the moon might come between the sun and the earth, thereby covering the sun from the earth ; an eclipse of the sun is formed (Fig. 7.7). As the earth is much bigger than the moon, only a portion of the earth can be within the total shadow of the moon at a time, and it is only from this portion that the sun cannot be seen. Other portions are either within the partial shadow or completely out of the region of the moon's shadow. The former would see the sun partially, while the latter would see it distinctly.

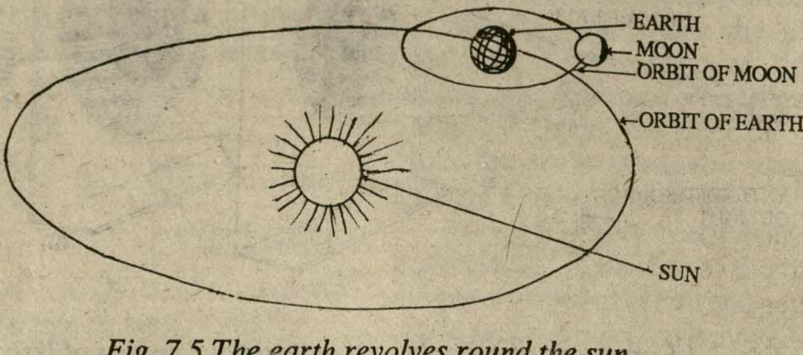


Fig. 7.5 The earth revolves round the sun.

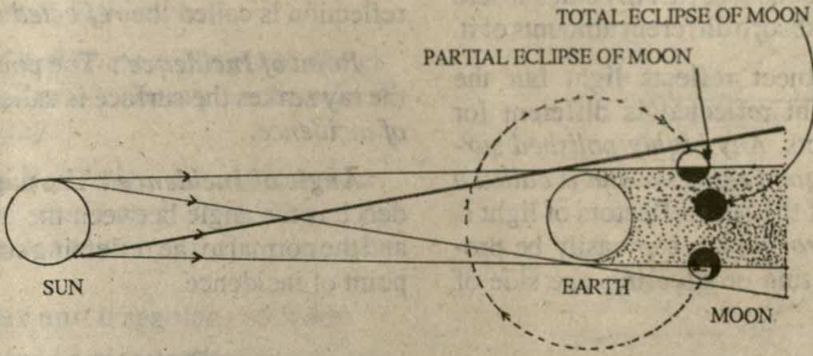


Fig. 7.6 An eclipse of the moon.

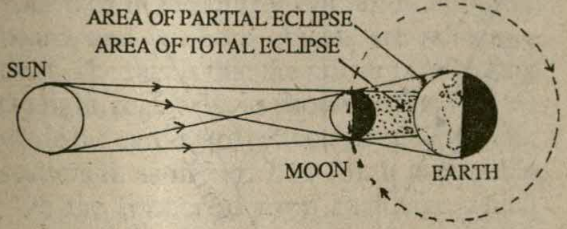


Fig. 7.7 An eclipse of the sun.

7.8 Pin-hole camera :

The pin-hole camera is a good illustration of straight line propagation. It consists of a rectangular wooden or card board box, on the front side of which there is a small hole in the centre. A ground glass screen is provided at the backside. For better result paint the inner surface of the box, black.

AB represents the flame of a candle, H the pinhole and A′ B′ the image of the candle flame.

The camera is so placed that the centre of the screen, the pinhole and the centre of the flame are in one straight line.

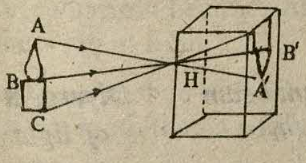


Fig. 7.8 Pin-hole camera.

Due to straight line propagation of light, rays from the point A and B pass through the pinhole and meet the screen at A' and B'.

A real, inverted image of the candle flame is formed on the screen. The image is quite sharp and clear.

Activity :

Measure the size of the flame, and on the screen, mark the height of the image. Also, measure the distance HB and HB'. Change the distance HB between the pinhole and the flame. Again measure the size of AB, A′ B′, HB and HB'. In each case you will observe that :

$$\frac{HB'}{HB} = \frac{A'B'}{AB}$$

7.9 Reflection of light :

When light falls on a body, three things can happen to the light :

(*a*) It can be sent back into the medium from which it was coming ; that is it can be *reflected.* It is this reflected light coming to our eyes that enables us to see the body.

(*b*) It can be allowed to pass through the body; that is, it can be ***transmitted.*** Only transparent and translucent bodies allow this, but different transparent and transluscent bodies transmit different amounts of light.

(*c*) It can be *absorbed*. All bodies absorb light, but they absorb different amounts of it.

Every object reflects light but the amount of light reflected is different for different objects. *Any highly polished surface can be a good reflector and is called a mirror*. One of the best reflectors of light is the ***plane mirror*** which can easily be produced by painting or silvering one side of plane glass.

Some Definitions :

Ray of light **:** The direction of path of light emanating from a source of light is called a ***ray of light.*** Rays are represented with straight lines with arrows marked on them.

Beam of light **:** It is a stream of light energy which is generally represented by number of rays of light. If the rays of light are parallel to each other, it is called a ***parallel beam*** of light. If the rays of light are approaching a point then it is called a *convergent beam* of light and if the rays of light are going away from each other then it is called a *divergent beam* of light.

Incident Ray **:** The ray coming to the reflecting surface is called the *incident ray*.

Reflected Ray **:** The ray going away from the reflecting surface after suffering reflection is called the *reflected ray*.

Point of Incidence **:** The point at which the ray strikes the surface is called the *point of incidence*.

Angle of Incidence **:** The angle of incidence is the angle between the incident ray and the normal to the reflecting surface at the point of incidence.

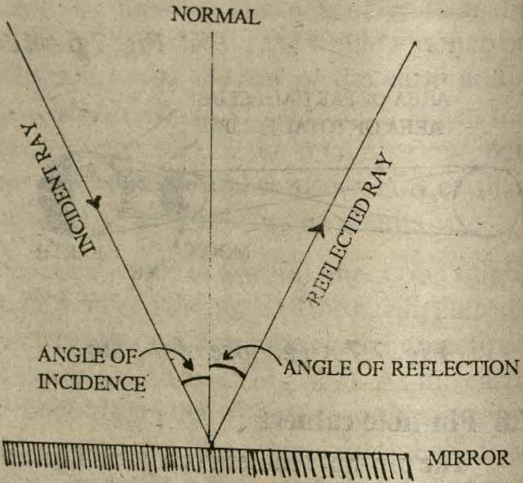
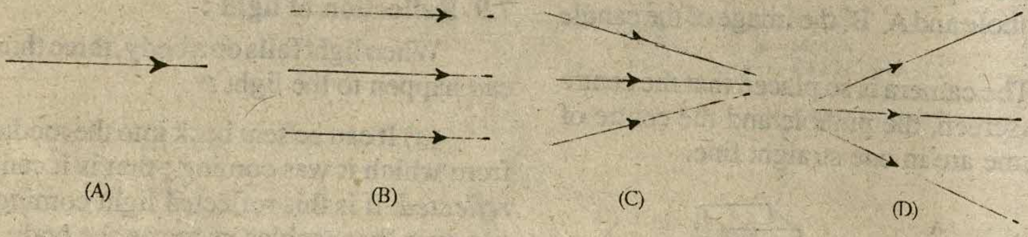


Fig. 7.10 Point of incidence

Angle of Reflection **:** The angle of reflection is the angle between the reflected



Ray of light *(a)*

Parallel beam of light *(b)*

Convergent beam of light *(c)*

Divergent beam of light *(d)*

Fig. 7.9

ray and the normal to the reflecting surface at the point of reflection which coincides with the point of incidence.

Plane of Incidence : The plane of incidence is the plane containing the normal and the incident ray.

Plane of Reflection : The plane of reflection is the plane containing the normal and the reflected ray.

7.10 Regular and irregular reflection

If you hold a plane mirror and a sheet of cardboard in front of you, you will see your face in the mirror but not in the cardboard, and yet both objects are reflecting light. The fact is that the mirror is reflecting the light, regularly, as shown in Fig. 7.11(a) while the cardboard reflects it regularly, *i.e.*, scatters it, as in Fig. 7.11 (b). It is possible with the former to form an image which appears behind the mirror, as you will see later, but the cardboard cannot form an image. In the same way the rough surface of a table scatters light but when it is polished the tiny holes are filled with polish so that the table now reflects light regularly and you are able to see your face in it.

Activity :

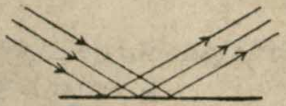
To test the truth of the laws of reflection.

Requirements :

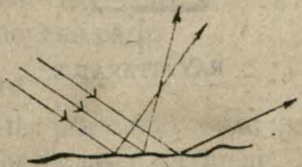
A mounted plane mirror, a ray apparatus, four pins and paper.

N.B. The ray apparatus is a piece of apparatus consisting of a lamp, a lens and a slit or slits arranged in such a way as to produce a very narrow beam of light commonly called a ray of light.

By using more than one slit it is possible to produce more than a single ray.



(*a*) REGULAR



(*b*) IRREGULAR

Fig. 7.11 Reflection

Procedure :

1st Method. Arrange the mounted plane mirror PQ (Fig. 7.12) so that it stands on one of its long edges, on a sheet of paper. In front of its place the ray apparatus R and use slit S to produce a single ray of light. Arrange this ray to strike the mirror. You will notice that it is sent back or *reflected* by the mirror. With a sharp pencil, mark two points B and C along the ray that goes to the mirror. This ray is called the *incident ray*. Mark two other points D and E along the ray that is sent back by the mirror. This ray is called the *reflected ray*. Now trace on the paper the position of the mirror PQ. Remove the mirror ; join the points B and C, and then the points D and E. Produce the two lines to meet at O.

Do your lines meet exactly on the line PQ ? They don't. This is because the back of the mirror, and not the front, is the reflecting surface. The lines should meet at the silvered back of the mirror.

Through the point O, use your set square to draw a line ON perpendicular to the mirror. Such a line is called the *normal* to the mirror. Also through O draw a line parallel to

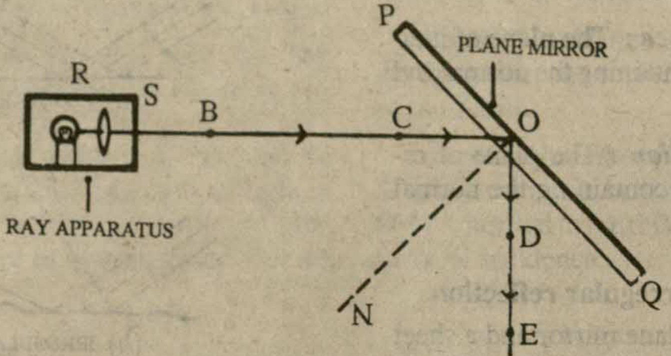


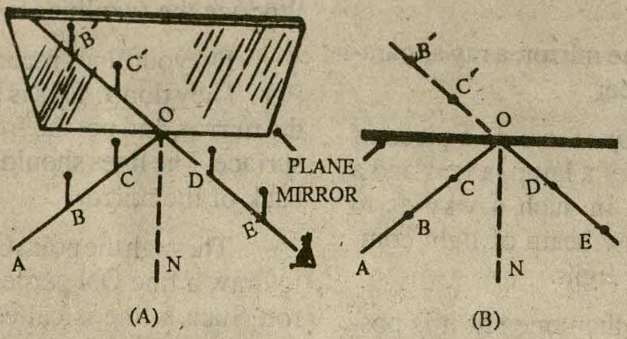
Fig. 7.12 Testing the truth of the law of reflection (1st method).

PQ. This line is the silvered back of the mirror where the reflection actually takes place.

Now measure the angle BON known as the *angle of incidence* and the angle EON known as the *angle of reflection.* What do you notice ?

Repeat the experiment twice using different angles and record your results as shown below :

Experiment	Angle of incidence BON	Angle of reflection EON
(*i*) Ray experiment	1.	
	2.	
	3.	
(*ii*) Pin experiment	1.	
	2.	
	3.	



(A) (B)

Fig. 7.13 Testing the truth of the law of reflection (2nd method).

2nd Method. Place the mirror on the paper as in the first instance. Draw a slanting line AO to meet the mirror at O (Fig. 7.13). Stick two pins B and C vertically on this line. Now set your eye along the direction shown in the diagram. You will see the images B' and C' of the pins in the mirror. Set your eye in the line with these two images and stick two other pins D and E on the paper in front of the mirror such that they are both in line with B' and C'. Now remove the mirror and the four pins after marking the position of each. Join BC, ED and produce them to meet at O. Proceed as for the first method. What do you notice again about angles BON and EON ?

Repeat the experiment twice, using different angles of incidence and record your results in a table.

Examine and compare the last two columns of your table. What do you notice ?

Two things can be noticed in these experiments.

(*a*) That the angle BON = angle EON, *i.e.*, the angle of *incidence* is equal to the angle of *reflection*, in every case.

(*b*) That in the ray apparatus method we actually see both the incident ray and the reflected ray on the plane of the paper, and in the pins experiment we actually see the tips of all the pins on the plane of the paper.

These two observations can be summed up by saying that when a ray of light is reflected by a mirror, it obeys these *two laws of reflection*.

(*a*) the angle of incidence is equal to the angle of reflection ;

(*b*) the incident ray, the reflected ray and the normal at the point of incidence all lie in the same plane.

And so with the above experiment we have verified the Laws of Reflection.

Activity :

To find the position of an object placed in front of a mirror.

Requirements :

A mounted plane mirror, a ray apparatus, one pin and paper.

Procedure :

Set the plane mirror and the ray apparatus as for the last experiment. Let the ray apparatus produce a broad beam of light on the paper. Erect a pin (O) vertically somewhere inside the beam. You will see a shadow of the pin going to the mirror and being reflected (See Fig. 7.14). With your pencil, trace the position of the mirror, mark the points A, B, C and D at the two edges of the shadow going to the mirror and the points E, F, G and H at the two edges of the shadow reflected from the mirror, as shown in the diagram. Remove the mirror. Join AB, CD, FE and HG and produce each to meet the mirror. Produce FE and HG behind the mirror to meet at I. Draw the Reflecting surface PN as you did in the last experiment. Join OI and let it meet PN at M. Measure MO, MI and the angle IMN. What do you notice ?

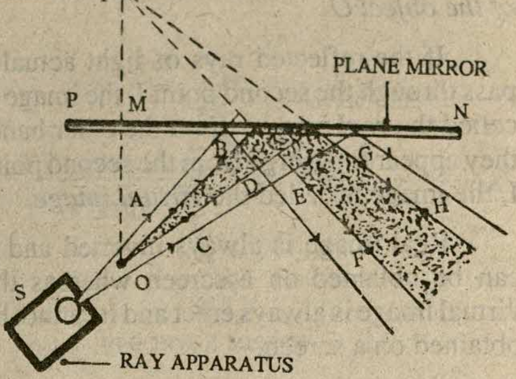


Fig. 7.14 To find the position of an object placed in front of a mirror.

Repeat the experiment twice.

If your experiment has been carefully done you will find that MO is equal to MI and that angle IMN is 90°. Thus you have found out that *the image (I) of an object (O) is as far behind the mirror as the object is in front of it.*

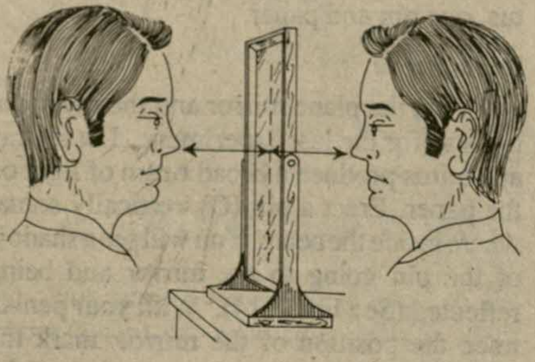


Fig. 7.15

When next you look at your face in a mirror you can tell your friend exactly where the image of your face is. (Fig. 7.15).

Image (or Optical Image) :

If a pencil of rays diverging from a point O, is caused by reflection to converge to or to appear to diverge from some other point, I, then the point I is called the image of the object O.

If the reflected rays of light actually pass through the second point I, the image is called the ***real image.*** If on the other hand, they appear to diverge from the second point I, the image is called the ***virtual image.***

Real image is always inverted and it can be obtained on a screen whereas the virtual image is always erect and it cannot be obtained on a screen.

In other words, an optical image of a point is the point of intersection, real or virtual, of the reflected rays of light. Hence in order to fix the position of an image of a point we have to trace the path of at least two rays by which it is formed.

An image of a finite object is the assembly of image points corresponding to objects.

7.11 How to find by geometrical construction the position of the image of an object placed in front of a plane mirror

Let MM′ be the plane mirror (Fig. 7.16) and AB the object in front of it. With the help of a set square draw AX and BY perpendicular to MM'. Produce AX to K and BY to L behind the mirror. Using a pair of compasses with X as centre and radius equal to AX, draw an arc to cut XK at A'. Again, with Y as centre and radius equal to YB, draw another arc to cut YL at B'. Join A' B'.

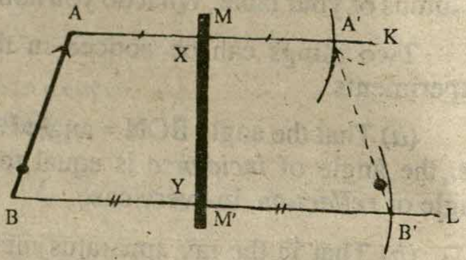


Fig. 7.16 To find the position of an image in a mirror using geometry.

A' B' is the image of object AB. Try and explain why this is so.

7.12 Lateral inversion :

If you look at yourself in a mirror while writing on a sheet of paper with your right-hand, you will be surprised to notice that you appear to be using your left-hand ; further, your left hair parting looks as if it were on the right ; finally, hold what you are writing against the mirror and you will not be able to

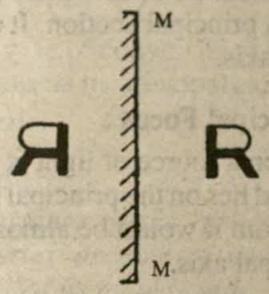


Fig. 7.17 Lateral Inversion

read your writing : In general, everything seems to have been turned round the other way ; the right becoming the left and the left becoming the right. *This sideways turning of the image obtained by reflection in a mirror is called **lateral inversion.***

You may like to try the following exercises :

1. Write something in ink on your paper and blot it immediately. Try to read what appears on the blotter. You cannot read it. Now hold it against the mirror and you can read it clearly.

2. Read the following word first by looking at it directly and then by holding it against the mirror (Fig. 7.17).

3. Try to tell the time by holding your watch or clock against the mirror.

The above three illustrations are further examples of lateral inversion, and you can reason out how it happens in each case.

7.13 Curved (Spherical) Mirrors :

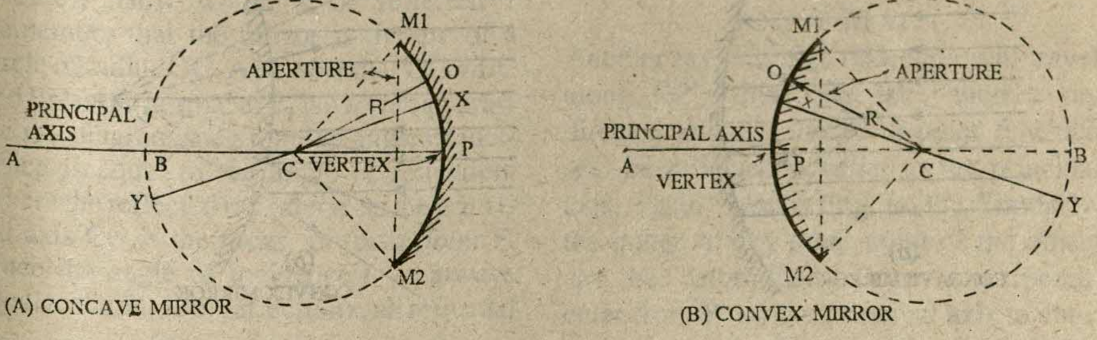
So far you have been studying the reflection of light from plane surfaces, but curved (spherical) surfaces also reflect light. A curved (spherical) mirror is a part of a hollow sphere or a spherical surface whose one side is silvered and other side is polished (Fig. 7.18). It is either ***concave*** or ***convex*** according as the reflecting surface is towards or away from, the centre of the sphere of which it forms a part [Fig. 7.18 (a & b) and Fig. 7.19 (a & b)].

A well polished tablespoon may be used to illustrate the two types of spherical mirrors. The hollow side of the spoon is a concave mirror, while the backside of the spoon is a convex mirror.

Before proceeding further certain physical terms relating to the spherical mirrors are defined below (See Fig. 7.18).

Centre of Curvature. The centre of curvature, C, is the centre of the sphere of which the spherical mirror forms a part.

Radius of Curvature. The radius of curvature is the radius OC or PC of the



(a) CONCAVE MIRROR

(b) CONVEX MIRROR

Fig. 7.18 Circular Sections of spheres form spherical mirrors.

sphere of which the spherical mirror is a part.

Normal. A radius drawn through a point on the spherical mirror is the normal to the mirror at that point. OC is the normal at O.

Vertex or Pole. The mid-point, P, of the spherical mirror is called its pole or vertex.

Linear Aperture. The diameter, M_1M_2 of the spherical mirror is called its linear aperture.

Angular Aperture. The angle M_1CM_2 subtended by the diameter of a spherical mirror at its centre of curvature is called its angular aperture.

Principal Axis. The straight line, PCB, passing through the *vertex*, P, the centre of curvature, C, of a spherical mirror is called its principal axis.

Secondary Axis. Any straight line, XY, other than the principal axis, passing through C, the centre of curvature of a spherical mirror, is called a secondary axis of the mirror.

Principal Section. A section of the spherical mirror cut by a plane passing through its centre of curvature and the pole is called a principal section. It contains the principal axis.

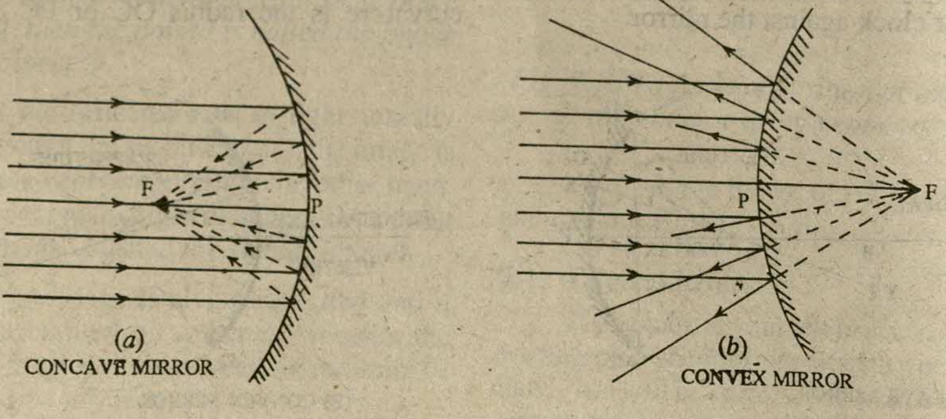
7.14 Principal Focus :

When a source of light is far from the mirror, and lies on the principal axis the rays of light from it would be almost parallel to the principal axis.

Let a beam of light parallel to the principal axis of a spherical mirror be incident on it near its pole. The reflected rays converge to or appear to diverge from, a point F (Fig. 7.19 (a&b)) on the principal axis. This point is called principal focus of the spherical mirror. Thus the principal focus of a spherical mirror may be defined as follows :

The principal focus of a spherical mirror may be defined as a point on its principal axis where a beam of light parallel to the principal axis converges to or appears to diverge from after reflection from the spherical mirror.

In the case of concave mirror, the principal focus lies on its principal axis *in front*



(*a*)
CONCAVE MIRROR

(*b*)
CONVEX MIRROR

Fig. 7.19

of it [Fig. 7.19(*a*)].

In the case of convex mirror, the principal focus lies on its principal axis *behind it* [Fig. 7.19(*b*)].

Focal Length :

The distance of the principal focus from the vertex or pole of the spherical mirror is called its focal length.

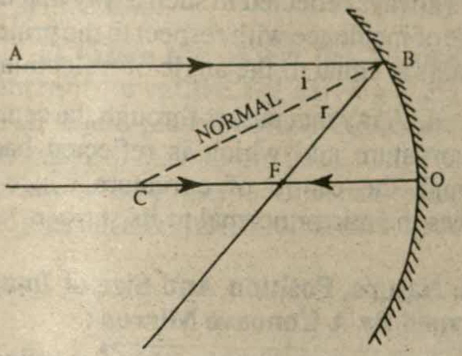


Fig. 7.19 (c)

The laws of reflection are the same for the plane mirrors and for curved mirrors. The angle of incidence is equal to the angle of reflection in both cases. Look at the ray AB falling on the concave mirror in Fig. [7.19(c)]. How would it be reflected ? Remember that the mirror is the arc of a circle of radius OC. Also note that OC = BC and BC is the normal at B. Now we can draw the ray diagram such that the angle of incidence is equal to the angle of reflection. Where the reflected ray intersects the principal axis CO is the *focus* or *focal point* F. Since the angle of incidence *i* is always equal to the angle of reflection *r*, all reflected rays will pass through F. Also OF = $\frac{1}{2}$ OC *i.e.*, for a spherical (or curved) mirror, the focal length FO is always half the radius of curvature CO.

7.15 Graphical Method for Locating Image

Let PQ be a small object placed on the principal axis of a spherical concave mirror M_1M_2 [Fig. 7.20(*i*)]. Since the object is an assembly of points, its image may be found as follows :

Consider a ray PA parallel to the principal axis. It strikes the spherical mirror at A. After suffering reflection, it passes through the focus F. Another ray PC passes through the centre of curvature of the concave mirror and as it strikes the mirror normaly at B it retraces its steps along BCP. The reflected rays AF and BCP actually intersect each other at P' which is the *real* image of P.

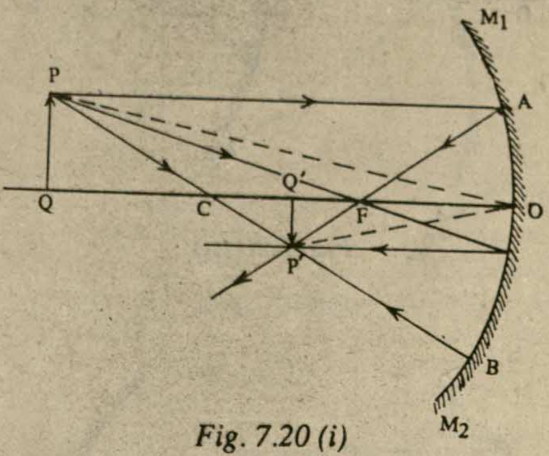


Fig. 7.20 (i)

Another ray PO after reflection will travel along OP'. One may take another ray directed towards the focal point F which will be reflected *parallel* to the principal axis, again intersecting at P'. Similarly, the image of any other point of the object can be determined. Draw a perpendicular from P' on the principal axis to cut it at Q'. It is clear from the Fig. 7.20 (*i*) that P' Q' is the real inverted and diminished image of PQ, where P' Q' has been drawn perpendicular to the principal axis since PQ is also perpendicular to the principal axis.

Following the above construction, we find that P'Q' is the virtual, erect and diminished image of PQ formed by a convex mirror [Fig. 7.20 (*ii*)].

The graphical method consists of drawing the rays emanating from key points on the object and locating the points at which these rays are focussed by the mirror. For this purpose four kinds of rays are of particular importance :

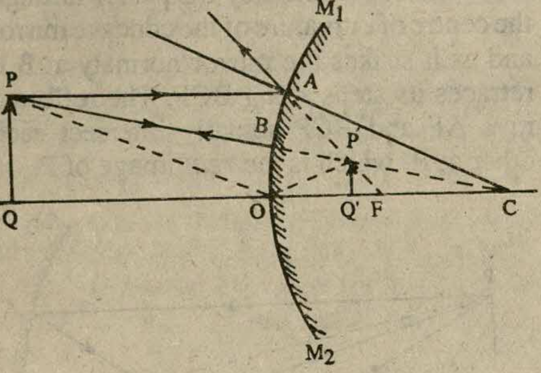


Fig. 7.20 (ii)

1. A ray that is parallel to the principal axis and which is always reflected through the principal focus F of the mirror.

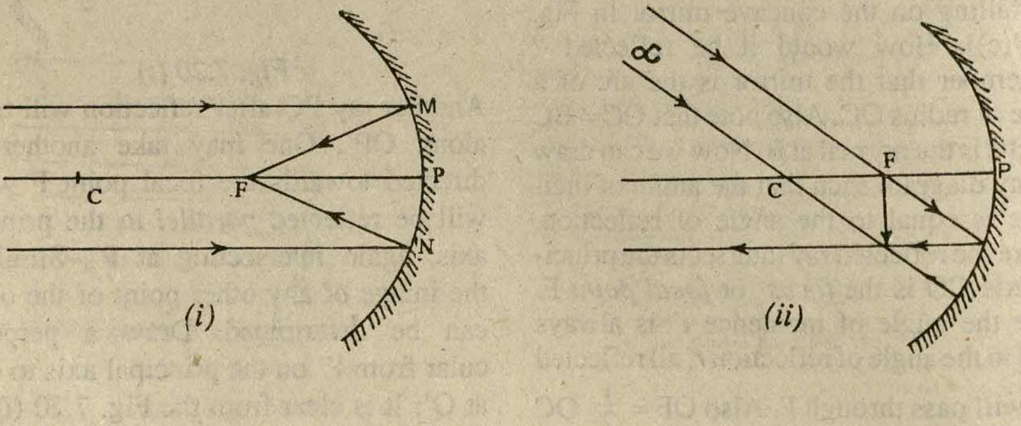
2. A ray that passes through the principal focus F first and which is then reflected parallel to the principal axis (the reverse of ray 1).

3. A ray which strikes the mirror at its vertex or pole (*i.e.*, the point at which the principal axis intersects the mirror). Such a ray is always reflected in such a way that the angle of incidence with respect to the principal axis is equal to the angle of reflection.

4. A ray that passes through the centre of curvature and which is reflected back through the centre of curvature, since it strikes the mirror normal to its surface.

7.16 Nature, Position And Size of Image Formed By A Concave Mirror :

Let us start with the object at infinity (*i.e.*,at a great distance) and gradually bring it nearer to the mirror. The following cases arise :



(*i*)

(*ii*)

Fig. 7.21(i) & (ii)

(*i*) **When the object lies at infinity :**

Here, the incident rays are all parallel to each other. Obviously, then, two cases arise, *viz* :

(*a*) *When the rays are parallel to the principal axis, [Fig. 7.21(i)], and (b), when they are not parallel to the principal axis, [Fig. 7.21(ii)].*

In either case, the rays after reflection at the mirror, converge to form a real, *inverted* and *extremely diminished image at the focus or focal plane.*

(*ii*) **When the object lies beyond the centre of curvature.** Let AB (Fig. 7.21(*iii*)), be an object, placed beyond C, the *centre of curvature of the mirror.* Then, a ray from B, *parallel to the principal axis,* passes through the *focus* F, after reflection at the mirror, and another ray from B, passing through the *focus* F, after reflection at the mirror, gets reflected parallel to the axis, so that the two reflected rays meet at B', which is therefore, the image of B. From B' drop a perpendicular B'A' on to the axis, to meet it in A', which is then the image of A. Thus, A'B' is the image of AB, and as is clear from the figure, *it is between the focus and the centre of curvature, and is real, inverted and diminished.*

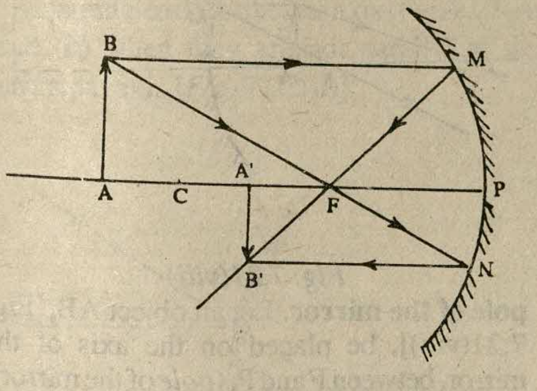


Fig. 7.21 (iii)

(*iii*) **When the object lies at the centre of curvature.** Let the object AB, (Fig. 7.21(*iv*)), lie at C, the *centre of curvature* of the mirror. Then, proceeding as in case (*ii*), *i.e.*, considering two incident rays from B, one *parallel to the axis*, and the other, passing through the *focus* F, we find that on reflection the former passes through F, and the latter becomes parallel to the axis, the two meeting to form an image of B at B'. Then, dropping A'B' perpendicular to the axis, we get the image A'B', of the object AB, which *also lies at the centre of curvature C, is real and inverted and of the same size as the object.*

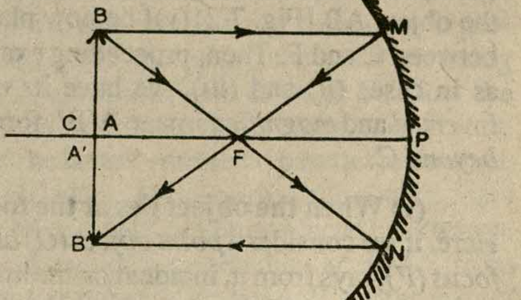


Fig. 7.21(iv)

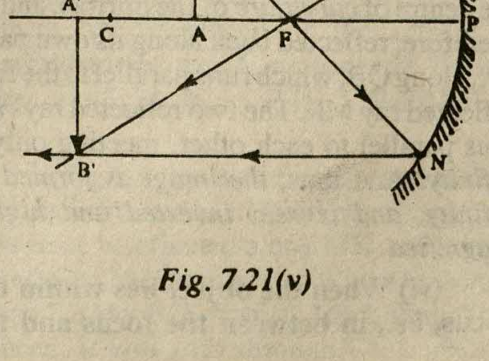
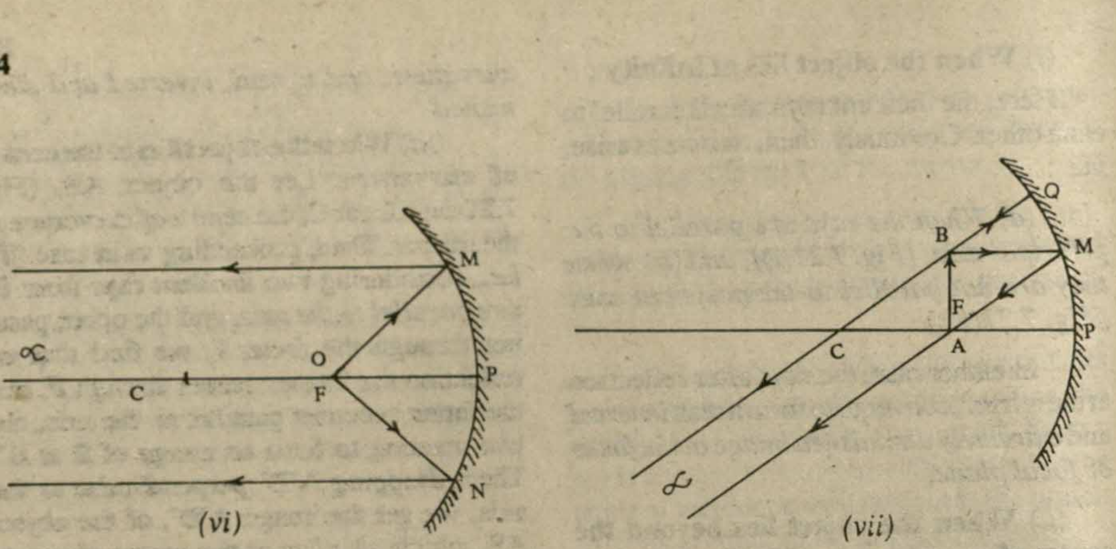


Fig. 7.21(v)



(vi) (vii)

Fig. 7.21(vi) & (vii)

(*iv*) **When the object lies in between the centre of curvature and the focus.** Let the object AB [Fig. 7.21(*v*)] be now placed between C and F. Then, proceeding exactly as in cases (*ii*) and (*iii*), we have its *real, inverted* and *magnified* image A'B', formed *beyond* C.

(*v*) **When the object lies at the focus.** Here, if we consider a *point object (O) at the focus (F)*, rays from it, incident on the mirror are rendered parallel to the principal axis, as shown in Fig. 7.21(*vi*). But, if we consider a *finite object* AB, [Fig. 7.21(*vii*)], at the focus, a ray BM, from B, incident parallel to the axis at M is reflected back along MF, passing through F. Another ray BQ from B is incident *normally* on the mirror at Q, (for, on being produced back, it passes through C, the centre of *curvature* of the mirror), and is, therefore, reflected back along its own path, *i.e.*, along QB, which runs parallel to the first reflected ray MF. The two reflected rays are thus parallel to each other, meeting only a *infinity*. And thus, *the image is formed at infinity, and is real inverted and highly magnified*.

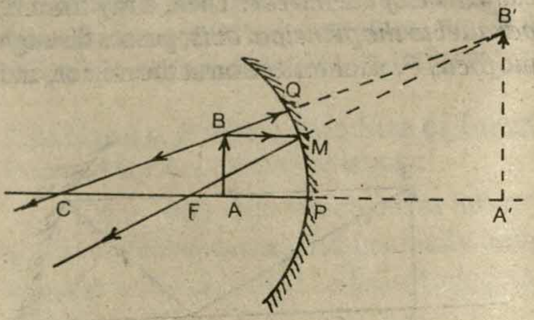


Fig. 7.21(viii)

(*vi*) **When the object lies within the focus, *i.e.*, in between the focus and the pole of the mirror.** Let an object AB, [Fig. 7.21(*viii*)], be placed on the axis of the mirror, between F and P, (*pole* of the mirror). Then, proceeding exactly as in case (*v*) above, we find that the two reflected rays MF and QB *appear to meet* at B', when produced backwards, and thus we get a *virtual, magnified and erect image* A'B' of the object AB, *behind the mirror.*

(*vii*) **When the object lies at the pole of the mirror.** If we have a small or a *point object* placed right on the *pole* of the concave mirror, then, since a small portion of it would just behave like a *plane* mirror, we shall have an image of the object, in accordance with the ordinary laws of reflection at plane surfaces, *i.e., image will also lie at the pole of the mirror and will be virtual, erect and of the same size, but laterally inverted.*

7.17 Nature, Position And Size of Image Formed by A Convex Mirror:–

In the case of a Convex Mirror only two positions of the object, are possible, *viz.*, (*i*) at infinity, and

(*ii*) between infinity and the pole of the mirror.

(*i*) **When the object lies at infinity.**

Here the rays are incident on the convex mirror and parallel to each other. Now, two cases arise, *viz.*, (*a*) when the rays are also parallel to the principal axis [Fig. 7.22(*i*)] and (*b*) when they are not parallel to the principal axis [Fig. 7.22(*ii*)].

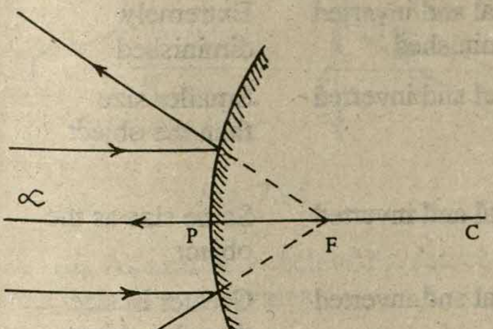


Fig.7.22(i)

In the former case the rays on reflection at the mirror, *appear to diverge* from the focus, F, thus giving a *virtual* and almost a *point-image* at the focus.

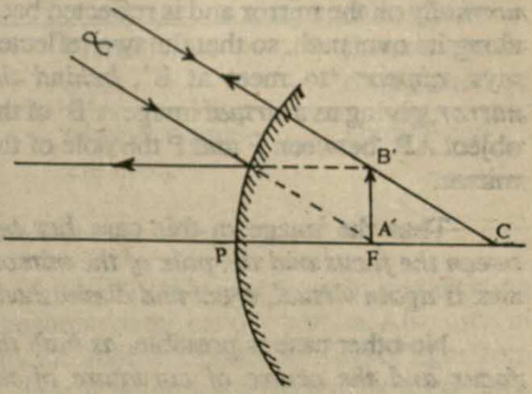


Fig. 7.22 (ii)

In the latter case, let us consider two parallel rays from the object one incident *normally* on the mirror, (*i.e., passing through the centre of curvature of the mirror* if produced), and the other, such that on being produced it will pass through F. Then the first ray is reflected back along its own path, and the latter is rendered parallel to the axis, on reflection at the mirror, the two *appearing to meet* at B', when produced backwards. On dropping a perpendicular, B'A', from B', on to the axis, we get A'B', as the *virtual image* of the object at the *focal plane.*

Thus, in either case, *the image lies at the focus and is virtual, erect and extremely diminished.*

(*ii*) **When the object lies between infinity and the pole of the mirror.** Let an object AB be placed on the axis of the convex mirror, with C, as its *centre of curvature*, and F, its *focus* [Fig. 7.22(*iii*)].

Then, a ray BM, from B, and incident on the mirror at M in a direction *parallel to the axis*, is reflected along MK, such that, if produced backwards, it will pass through F. Another ray BQ, from B, (such that, if produced, it will pass through C), is incident *normally* on the mirror and is reflected back along its own path, so that the two reflected rays, *appear* to meet at B', *behind the mirror*, giving us a *virtual* image A'B' of the object AB, between F and P the pole of the mirror.

Thus the image in this case *lies between the focus and the pole of the mirror, and is again virtual, erect and diminished.*

No other case is possible, *as both the focus and the centre of curvature of the mirror lie on the back side of the mirror.*

And since the object and image travel in opposite directions, the image moves from F towards P as the object moves from infinity towards P but *is always virtual, erect and diminished.*

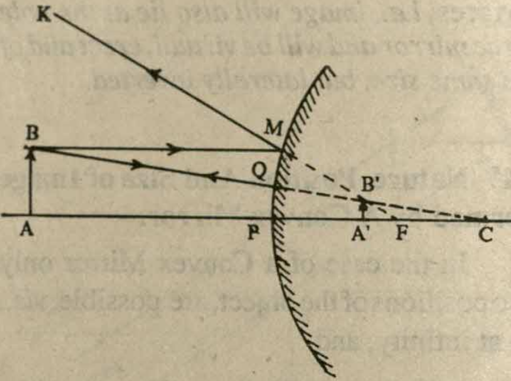


Fig. 7.22 (iii)

Summary:

CONCAVE MIRROR

Position of the object	Position of the image	Nature of the image	Size of the image
At infinity	At Principal focus	Real and inverted diminished	Extremely diminished
Beyond Centre of curvature	Between Principal focus and centre of curvature	Real and inverted	Smaller size than the object
At Centre of curvature	Also at centre of curvature	Real and inverted	Same size as the object
Between principal focus and centre of curvature	Beyond centre of curvature	Real and inverted	Greater in size than the object
At Principal focus	At infinity	Real and inverted	Highly magnified
Between pole and principal focus	Behind the mirror	Virtual and erect	Magnified
At the pole	Also at the pole	Virtual, erect, Laterally inverted	Same size as the object

CONVEX MIRROR

At infinity	**At focus**	**Virtual and erect**	**Extremely diminished**
Between infinity and pole of the mirror	Between pole and the focus	Always virtual and erect	Diminished

7.18 Applications of Spherical Mirrors :

Spherical mirrors are being used for following mentioned purpose :

(*i*) As a shaving mirror (Fig 7.23). When we keep the face closer to the principal focus of the mirror, a virtual, erect and enlarged image is formed behind the mirror.

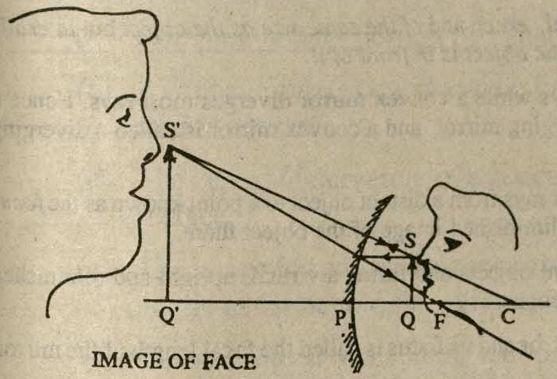


Fig. 7.23

(*ii*) As a reflector behind the source to direct light in a given area.

(*iii*) In the construction of astronomical telescopes.

(*iv*) Used by doctors while examining the throat or the ear of a person. Also used in doctor's ophthalmoscope. Rays of light from a distant lamp are reflected by a concave mirror and concentrated on a throat or a tooth or inside the ear to illuminate it for examining it.

(*v*) Used in search light. If an electric bulb is kept at the focus of a concave mirror, then the reflected light comes out as a parallel beam and travels long distance. In an automobile the head lights or in a search light or in a hand torch, the reflectors are often concave mirrors.

(*vi*) Convex mirror is used as a driver's mirror on buses, trucks, cars, etc. (Fig. 7.24).

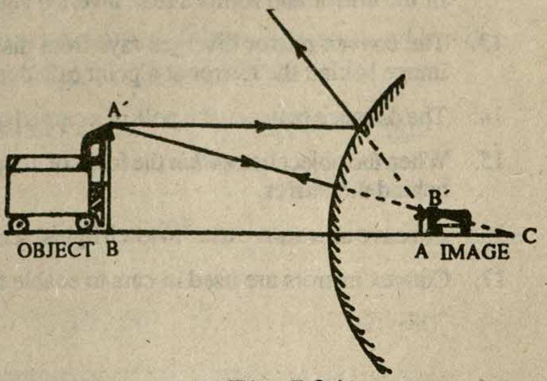


Fig. 7.24

Summary

1. Our chief source of light is the sun. The sun, the stars and the moon are natural sources of light. A large number of artificial sources of light are also in use.
2. A source of light spreads light in all directions. Some sources of light are brighter than the others. Eye helps human being to detect light.

3. *Self–luminous bodies give* out light of their own. *Non–luminous bodies* do not give out light of their own, but are seen by the light they reflect.
4. *Transparent bodies* allow light to pass through them, and we can see other objects through them.

   Translucent bodies allow light to pass through them, but we cannot see other objects through them.

   Opaque bodies do not allow light to pass through them, nor can we see other objects through them.
5. Light travels in straight lines. Because of this, it is possible to make a pin–hole camera which can actually take photographs but will require a long exposure.
6. The same property of light can be used to explain the formation of shadows and eclipses : a point source of light produces a uniform shadow of an opaque object ; an extended source of light produces a dark shadow (umbra) sorrounded by a less dark one (penumbra).
7. When the shadow of the earth falls on the moon an eclipse of the moon is produced.

   When the shadow of the moon falls on the earth, the sun is covered from view and an eclipse of the sun is produced.
8. A beam of light may be reflected, transmitted or absorbed.
9. Laws of reflection of light :

   (*i*) The angle of incidence is always equal to the angle of reflection.

   (*ii*) The incident ray, the reflected ray and the normal at the point of incidence are all in the same plane.
10. The image formed by a plane mirror is *virtual, erect* and *of the same size as the object* but *laterally inverted* and *is as far behind the mirror as the object is in front of it.*
11. A concave mirror converges most of the rays while a convex mirror diverges most rays. Hence a concave mirror is sometimes called a converging mirror and a convex mirror is called a diverging mirror.
12. The concave mirror converges parallel rays or rays from a distant object to a point known as the *focus* of the mirror and forms a real, inverted and diminished image of the object there.
13. The convex mirror diverges rays from distant objects and forms a virtual, upright and diminished image behind the mirror at a point called its focus.
14. The distance between the pole of a curved mirror and its focus is called the focal length of the mirror.
15. When the object lies *within* the focus of a concave mirror, a virtual, erect and enlarged image is formed behind the mirror.
16. Concave mirrors are used in torch lights, search lights, in special mirrors for shaving and in telescopes.
17. Convex mirrors are used in cars to enable the driver to see other cars approaching from behind.

Questions

(A) Objective Type Questions :

1. Fill in the blanks with suitable words :

   (*i*) .... surfaces act like mirrors.

(*ii*) If we throw a ball towards the plane mirror, the image of the ball appears to be moving .... the surface of the mirror.

(*iii*) The image formed by a convex mirror is .... and .... than the size of the object.

(*iv*) Eye helps human beings to detect ....

(*v*) The nature, size and position of the image formed depends on the relative position of the .... and ....

(*vi*) A .... is formed when the path of light is obstructed by an .... object.

(*vii*) Reflection of light follows definite rules called ....

(*viii*) Solar eclipse occurs only on .... moon days.

(*ix*) Lunar eclipse occurs only on .... moon days.

2. Write true (T) or false (F) against the following statements :

(*a*) Moon is a non–luminous source of light.

(*b*) Completely dark portion of a shadow is called umbra.

(*c*) A concave mirror covers a wider field of view and hence it is used as a back view mirror in cars.

(*d*) The centre of curvature of a concave mirror lies in front of its highly polished surface.

(*e*) The image formed by a plane mirror is erect, virtual, laterally inverted but does not lie as far behind the mirror as the object is in front of it.

(*f*) Cinema screen in a cinema hall produces .... reflection of light.

3. Choose the correct answer :

(*i*) A ray of light falls on a plane mirror at an angle of 40° with the normal. The angle of reflection is :

(*a*) 20° (*b*) 40° (*c*) 60° (d) 80°

(*ii*) To get the image formed by a concave mirror of the *same size* as the object, the object must be placed :

(*a*) at infinity
(*b*) at its centre of curvature
(*c*) at the pole of the mirror
(*d*) between the focus and the centre of curvature.

(*iii*) Stained glass found mostly in modern houses and schools is an example of :

(*a*) transparent body (*b*) translucent body

(*c*) opaque body (*d*) None of these.

(B) Very Short Answer Type of Questions :

1. Name two natural sources of light.
2. Name two artificial sources of light.
3. Name two luminous (hot) sources of light.
4. Name two non–luminous sources of light.
5. Which is a brighter source of light—electric bulb or the sun ?
6. Give two examples of transparent objects.
7. Give one example of a translucent object.
8. Do wood, lead, a piece of stone allow light to pass through them ?
9. What is a shadow ?
10. Define umbra.
11. What is penumbra ?
12. Define an eclipse.
13. Mention one practical application of the fact that light travels in a straight line.
14. Mention two uses of concave mirror and one use of convex mirror.
15. Where should an object be placed in front of a concave mirror to obtain its magnified erect image ?

(C) Short Answer Type and Essay Type Questions :

1. Explain the terms : luminous, non-luminous, transparent, translucent, opaque. Give examples of bodies that can be so described.
2. Classify the following under transparent, translucent and opaque :
   diamond ; the moon ; the stars ; the planets ; a sheet of paper dipped in oil ; the sun ; water ; palm oil.
3. (*a*) What is the chief source of light energy ?
   (*b*) How will you show by an experiment that light travels in a straight line ?
4. (*a*) What are the two things needed for vision ?
   (*b*) What is a pinhole camera ? Upon what principle does it work ? Explain how it forms an image of an object. What is the nature of the image formed by it ?
5. What is the difference between a mirror and a glass sheet ?
6. Why do some mirrors show distorted images ?
7. Are the images in curved mirrors of sizes different from the size of the object ?
8. (*a*) What is the principal focus of a :
   (*i*) concave mirror, (*ii*) convex mirror ?

(*b*) Draw diagrams showing how a
  (*i*) concave mirror can form an enlarged upright image, and
  (*ii*) convex mirror can form a virtual image.

9. State the three things that may happen to a beam of light striking a body.
Which of the three of most likely to occur when a beam of light strikes the following :
(*a*) a plane mirror (*b*) a plane glass (*c*) a polished table
(*d*) coal tar (*e*) a perfectly transparent body
(*f*) a piece of diamond (*g*) a black cloth
(*h*) water (*i*) stained glass.

10. (*a*) You can see your face in a polished top of a table but you cannot see it when it is not polished. Explain.

(*b*) State the laws of reflection of light. Draw a ray of light incident at 45° on a plane mirror. Draw the normal and the reflected ray. What is the angle through which the ray has been turned from its original direction ?

(c) Is the image produced by a plane mirror real or virtual, erect or inverted ; enlarged, the same size or smaller ?

11. (*a*) How can you tell the difference between concave and a convex mirrors by looking at your face in each ?

(*b*) How can a concave mirror be used :
  (*i*) to burn a piece of tissue paper ;
  (*ii*) to send out a parallel beam of light ?

(*c*) Use diagrams to show why concave mirrors are called converging mirrors while convex mirrors are called diverging mirrors.

12. Describe the series of images formed by (*a*) a concave mirror, (*b*) a convex mirror, as the mirror is moved from a position near the face to about 100 cm away.

13. What advantages, as a driver's mirror, does a convex mirror have over a plane mirror ?

14. What changes would you observe in your image as you moved nearer to :
(*i*) a plane mirror ; (*ii*) a concave mirror ; and (*iii*) a convex mirror.

15. Define :
  (*i*) Pole of a mirror
  (*ii*) Centre of curvature of a mirror
  (*iii*) Radius of curvature of a mirror
  (*iv*) Principal focus of a mirror and a lens
  (*v*) Focal length of a curved mirror and a lens.

Show them by means of diagrams.

16. Define an image. Distinguish between a real image and a virtual image. Give an example of each.

17. How will you verify laws of reflection experimentally ?

18. A lady wishing to pin a flower on the right side of her head, pins it on the left side while looking into the plane mirror ? Explain why ?

19. Construct a ray diagram to show the formation of an image by a concave mirror when the object is at a distance beyond the centre of curvature. Describe fully the image that is formed.

20. What kinds of mirrors could be used and where should the object be placed to produce :

    (*a*) an enlarged real image
    (*b*) a reduced real image
    (*c*) a real image, the same size as the object
    (*d*) an enlarged virtual image
    (*e*) a reduced virtual image ?

21. Construct a ray diagram to show the formation of an image by a concave mirror when the object is between the principal focus and the centre of curvature. Describe fully the image that is formed.

22. Draw diagram to show how a convex mirror can be used to give a large field of view.

23. Draw a labelled diagram to show how a converging (concave) mirror may be used to produce wide parallel beam of light. State one different use of a converging mirror.

24. Which of these objects are luminous :
    Camera, firefly, mirror, a car bumper, filament of a bulb, diamond ?

25. "The tube light is a cold source of light". Is this statement true? If so, why ?

26. Explain what is meant by *earthlight.*

27. Draw the diagram of
    (*a*) a solar eclipse
    (*b*) a lunar eclipse.

28. A metrestick dropped a shadow of length 70 cm in the sun. At the same time, a tree dropped a shadow 5.6 metre long. What is the height of the tree ?
    Is there a particular time on a sunny day when this ratio method may not work?

29. What should be the shape of an object so that it will cast no shadow (or very little) on the ground in sunlight ?

30. (*a*) How many reflected rays can there be for a given single incident ray falling on a plane mirror.

(*b*) Can you guess how light would be reflected from a mirror if the angle of incidence is 90 degrees ?

31. What is a periscope ? How does it work ?

32. Barber shops have two mirrors hanging on opposite walls facing each other. How many images of yourself can you see if you stand before them ? Why ?

33. Two plane mirrors are kept at 90° to each other as shown in Fig.(7.25).The incident beam AB is shown as falling on one of the mirrors PQ at an angle of 20°. Draw the path of the ray and show the path of the reflected ray.

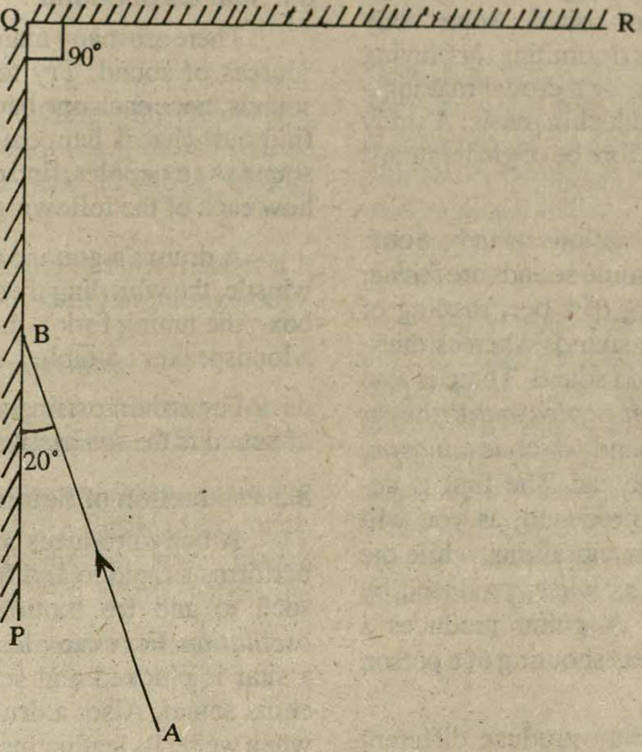


Fig. 7.25

□ □

CHAPTER 8

SOUND

8.1 Types of Sounds :

The ordinary world is full of sounds of enormous variety : the hum of a fan, the buzz of a fly, the putt-putt of a lawn mower, the whistle of a tea kettle, humming of a bird ; sounding of a siren, rustling of leaves. There is hardly any time of the day in which you do not hear some sort of sound : some body talking, or singing, or drumming, or playing a musical instrument, or a crowd making a noise, or the radio producing music. A study of sound should therefore be of great interest to you.

Try to listen to various sounds. Some sounds are *loud* and some sounds are *feeble*. For example, buzzing of a bee, rustling of leaves etc. are feeble sounds whereas thunder of a cloud is a loud sound. There is also a sound which is *sweet* or *pleasant* to the ear and there is also a sound which is *annoying* or *unpleasant* to the ear. The first is described as *musical*, produced, as you will learn later, by regular vibrations, while the second is described as *noise*, produced by irregular vibrations. A guitar produces a musical sound whereas shouting of a person produces a noise.

Some source may produce different types of sound under different conditions. Try to watch a guitarist playing. He makes use of his left fingers (if he is right-handed) to alter the lengths of the vibrating wire in order to produce different types of sounds. A single wire can give about four different sounds (notes) so that if there are five wires it will be possible to have twenty different sounds (notes). There are bridges below the wires which enable him to do this easily.

When you play a flute you cover and open certain holes with your fingers, and different types of sounds are produced.

8.2 Sources of Sound :

There are many man-made and natural sources of sound. Try to listen to various sounds, trace each one back to its source and find out what is happening to produce the sound. As examples, find out and write down how each of the following produces sound :

A drum ; a guitar ; a piano ; a sitar ; a whistle, the whistling tree ; the human voice box ; the tuning fork ; the radio ; a violen ; a loudspeaker ; a table ; a siren.

For us the most important natural source of sound is the *human voice box* or *larynx*.

8.3 Production of Sound :

A body produces sound only when it performs a rapid to and fro motion. We call such to and fro motion — *vibration* or *oscillation*. For example, when the string of a sitar is plucked and set into vibration, it emits sound. Also, a drum produces sound when we set its leather membrane into vibration by striking it with a stick. Thus, sound is produced due to the vibrations in a body. In some cases, the vibrations are easily visible to our naked eyes but in some cases they are so small that we feel them with our palms. Hold the flat of your palm gently against your throat. Recite your favourite poem. The throat would vibrate so little that we could only feel the vibrations.

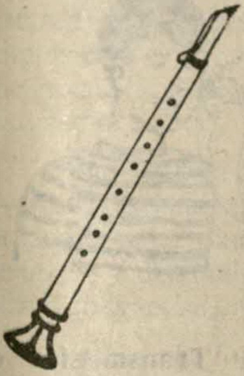


Fig. 8.1 (a)

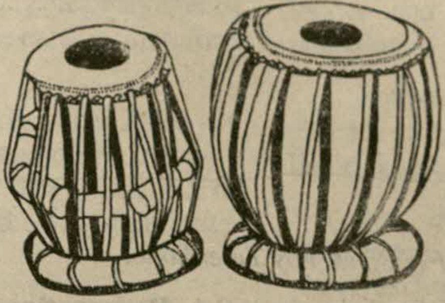


Fig. 8.1 (b)

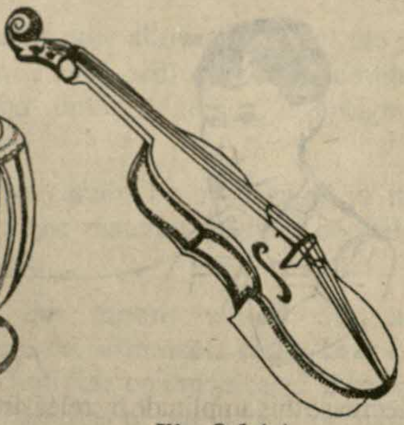


Fig. 8.1 (c)

Activity:

Bring a suspending pith ball near a vibrating tuning fork. The pith ball will be thrown off with a jerk as shown in Fig. 8.1(d).

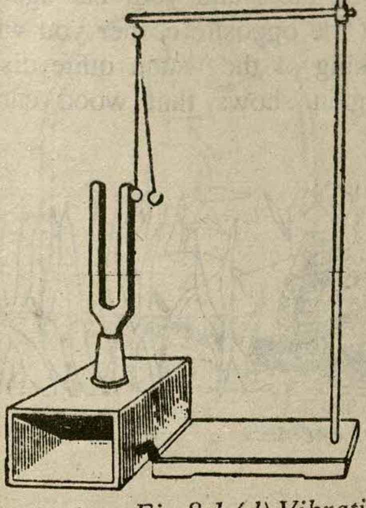
It will behave in the same manner if it is made to touch any other sounding body.

Vibrations or Oscillations :

We have seen that *Vibration* or an *Oscillation* is a repeated to and fro motion.

Take a small piece of stone and tie it to the end of a cotton string. Suspend the cotton string along with the piece of stone from a height as shown in Fig 8.1(*e*). Move the stone to one side and release it. What motion does the stone perform ? The stone moves say from right to left and then back to the right. It does so repeatedly. After a while this motion stops and the stone comes to rest. The motion is very much like a swing in the park.

The oscillations of the stone can be large or small, depending on how high you lift the stone before you release it. The distance to which the stone goes from its central position has a special name. It is called the *amplitude* of the oscillation. We can increase the amplitude of oscillation by increasing the height from which the stone is initially released. Similarly we can also



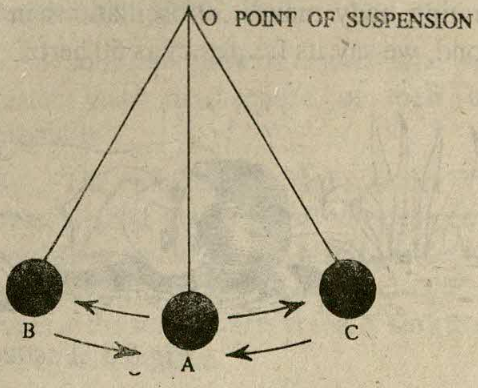


Fig.8.1 (d) Vibration in a sounding body. (*e*)

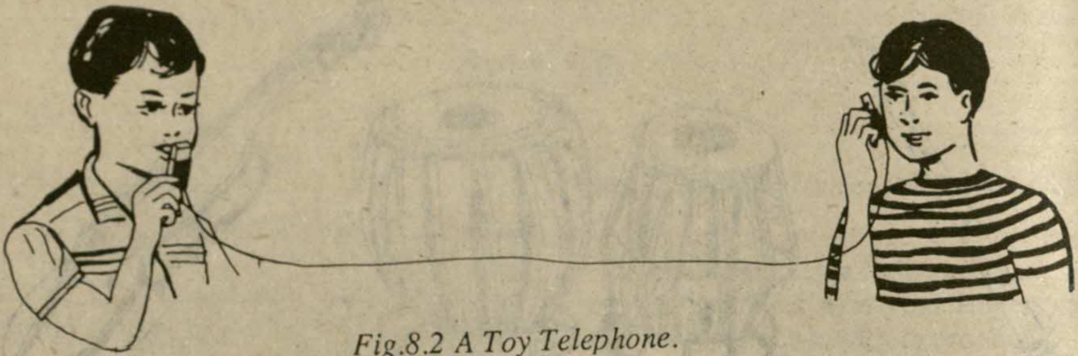


Fig.8.2 A Toy Telephone.

decrease this amplitude by releasing the stone from a smaller height.

When the stone goes from one extreme position say 'B' to the other extreme position 'C' and then back to 'B' we say that it completes one *oscillation* or *vibration*. This oscillation took some time. The time taken to complete one oscillation or vibration is called the *time-period*. Can you find the number of such oscillations in one second ? You can easily do this if you count the number of oscillations in 60 seconds. This is the number of times the stone goes from left to the right and then back to the left in one minute. Dividing this number by 60 will give you the number of oscillations in one second.

The number of oscillations or vibrations made by a vibrating body in one second is called the **frequency** *of the oscillation.* Frequency is measured in *hertz* (Hz). If a vibrating body makes 50 oscillations in a second, we say its frequency is 50 hertz.

8.4 Propagation or Transmission of Sound:

Sound can be produced by a vibrating body but it will not be heard until it reaches the ear of the listener. Transmission of sound is as essential as its production. *Sound requires a material medium for its propagation.*

When your teacher speaks to you, you hear him easily which means that at least air can carry sound.

Have you played with a toy telephone before *i.e.* two match boxes connected by a long string with two boys standing either end. This shows without doubt that sound can pass through a string (Fig.8.2).

If you place your watch at one corner of a long table and your ear against the table at the opposite corner you will hear the ticking of the watch quite distinctly. This again shows that wood can carry sound.

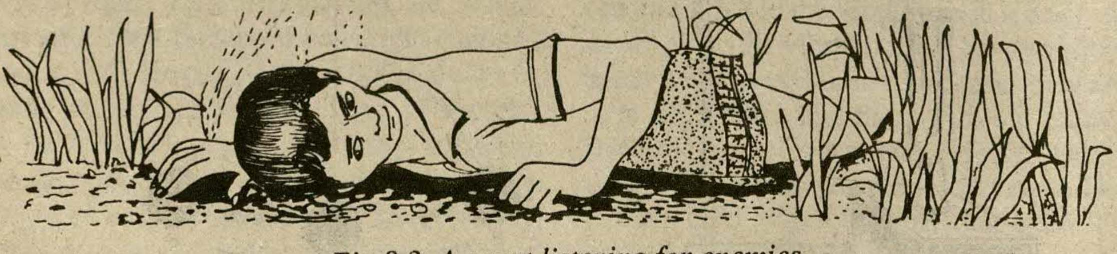


Fig.8.3 A scout listening for enemies

Have you read the story of how scouts listened to sounds of soldiers marching many kilometers away by placing their ears against the ground (Fig.8.3). The earth is, therefore, a carrier of sound.

While swimming in water have you ever tried to listen to a sound *e.g.*, clapping produced under water ? The sound will be heard very distinctly, showing that water also carries sound.

Now try the following activity :

Activity:

Arrange an electric bell inside a glass bell jar on the receiver of vacuum pump (Fig.8.4).

Sound requires a medium for its propagation. Place a ticking clock upon a thick piece of rubber inside the bell jar.

Now start taking out air from the jar. As the air is taken out, the loudness of the ticking sound goes on decreasing until the sound becomes too faint to be audible even though the clock is ticking as before.

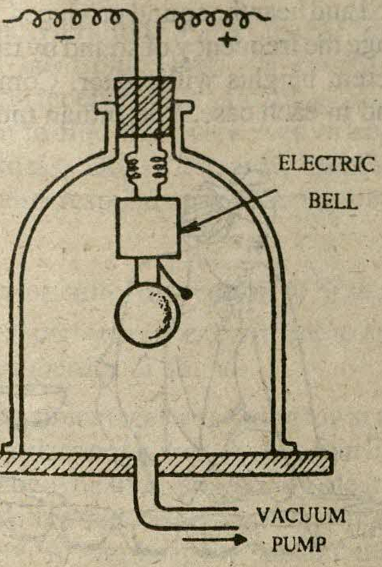


Fig. 8.4

If air is now allowed to enter the jar gradually, sound will go on becoming louder and until it attains its original intensity.

Sound cannot be propagated in the absence of the material medium of solid, liquid or gas.

On the moon, which has no atmosphere, the astronauts could hear no sound except that communicated through the solid surface of the moon or radio waves.

The vibrations of a sounding body produces disturbance in the surrounding medium. The progressive transmission of a disturbance from point to point in a material medium or in space is termed as a *wave*. The wave motion can occur only in a medium which possesses the properties of elasticity and inertia.

8.5 Speed of Sound :

It is a common experience that thunder is heard several seconds after the flash of lightning is seen in the sky. This is because the speed of light is enormous in comparison to that of sound. The speed of sound in dry air is approximately 332 m/s at 0°C. The speed of sound increases by about 0.61 m/s for every 1°C rise in temperature of the air.

Solids and liquids can transmit sound faster than air because of their large elasticity.

The velocity of sound in water is five times higher, about 1.5 kilometres per second. That sound can be heard inside water and so rapidly is very important to the creatures in the sea. Whales actually sing to each other under water.

8.6 Characteristics of Sound (loudness and pitch) :

Any vibration or oscillation has an amplitude and a frequency. The amplitude tells us how far the object travels from its central position. The frequency tells us how fast it repeats its motion.

The sound produced by various vibrating bodies (human voices, musical instruments etc.) are distinguished from each other by some of their characteristics such as *loudness* and *pitch*.

When we speak softly, our voice may not be heard after a little distance but if we speak with greater force, our voice may reach longer distances.

Sometimes, to make our voice louder, we make use of a microphone and loudspeaker.

A big drum produces a louder sound than a tabla with a small vibrating surface.

All string instruments are provided with an air box to make the sound louder.

The loudness of sound depends on the amplitude of vibration.

When the amplitude of vibration is large, we say that the sound is loud.

Loud sound can cause great harm to our ears and in some cases can even damage them permanently. Loud sound can even shatter a thin sheet of glass.

Activity :

Place the base of a vibrating tuning fork on a bench. The sound will become louder. Why ?

Pitch or shrillness of sound depends upon the frequency of the sound wave. *The greater the frequency, the greater will be the pitch or shrillness*. For example the voice of a child or a woman has a higher frequency than the voice of a man.

You must have seen a *tabla* or a *mridangam* player tightens the membrane of the instrument using a hammer or a stone. A tight membrane vibrates at a much higher frequency than a loose one, so that the sound produced has a higher pitch.

Activity :

Turn a bicycle upside down and spin the back wheel. Hold a piece of card on the spokes of the wheel. Observe the sound produced as the wheel is speeded up. You will notice that the pitch is higher when the wheel rotates fast.

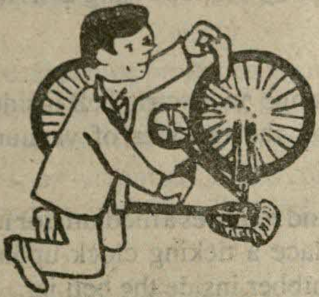


Fig. 8.5 (a) Pitch increases with increase in speed of rotation.

Activity :

Take a metal tumbler half filled with water. Tap the edge of the tumbler with a pencil and hear the sound produced. You can change the frequency of sound by filling it to different heights with water. Compare the sound in each case. The Indian musical in-

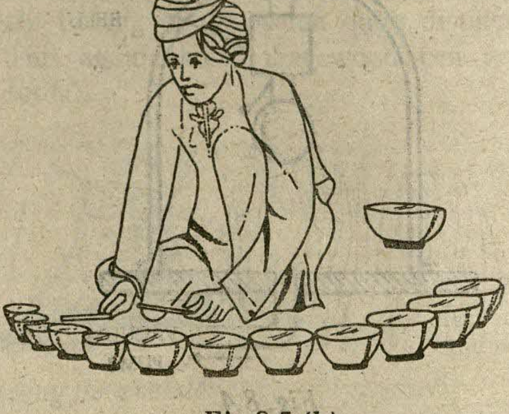


Fig.8.5 (b)

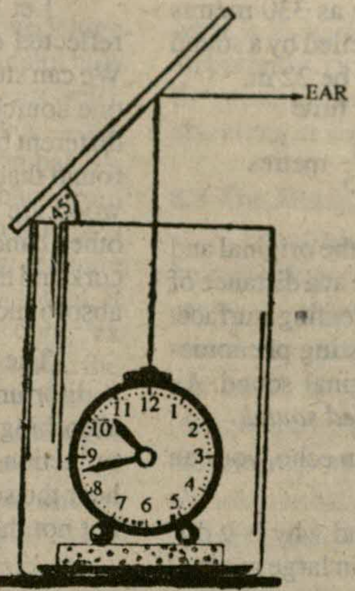


Fig. 8.6 Set-up of an experiment to observe reflection of sound.

strument called the *Jal-tarang* shown in Fig 8.5 (*b*) uses the principle you have learnt from this activity.

The human ear responds normally to sound frequencies between 20 hertz and 20,000 hertz. The sound of the human voice is in the range of 60 hertz to 13,000 hertz.

Sound vibrations above 20,000 hertz are called *ultrasonic*. Bats are known to generate and receive ultrasonic sound which helps them to find their way even in complete darkness. Dogs, leopards, monkeys and deer also respond to ultrasonic vibrations.

8.7 Reflection and Absorption of Sound :

Let us perform an experiment to find out other properties of sound.

Keep a timepiece or a ticking toy at the bottom of a glass container, as shown in Fig. 8.6. We cannot hear the sound very clearly. Hold a smooth wooden sheet as shown in the figure. Now we can hear the sound better. What is the reason ? The sound starts from the watch and reaches the sheet.

At the sheet, the direction of the sound waves changes and we hear the sound. This phenomenon is called *reflection of sound.*

Let us see how we listen to a person speaking in a room. When he speaks, the sound waves spread in the air in all directions. Some sound waves reach our ear directly and some strike the walls. The sound waves striking the walls get reflected and also reach our ears.

In the case of small size, all the reflected sound waves reach our ear at about the same time.

What happens when the sound waves reach our ears directly and also after reflection from a distant object ?

The human ear can listen two sounds separately only if they reach the ear after an interval of 1/15th of a second. This is a natural feature of the human ear. If we take the speed of second roughly as 330 metres per second, the distance travelled by a sound in 1/15th of a second would be 22 m.

$$\text{Distance} = \text{Speed} \times \text{time} = 330 \times \frac{1}{15} \text{ metres} = 22 \text{ m}$$

This means that we can hear the original and the reflected sounds if we are at a distance of 11m or more from the reflecting surface. This results in a very interesting phenomenon, called *echo* of the original sound. *An echo is thus simply a reflected sound.*

If you have not heard an echo, you can now try to hear one.

Can we now understand why is it difficult to hear sounds clearly in large rooms ?

The reflection of sound is used for measuring ocean depths. A short sound signal sent from the ship towards the bottom of the sea returns to the ship after being reflected from the bottom. Knowing the speed of sound in sea water and the required to cover the distance from the ship to the bottom and back, we can determine the depth of the ocean.

Let us now study whether sound is reflected equally from different materials? We can study this by hearing the sound from one source or sounds being reflected from different bodies. Experimentally, it has been found that metallic sheets and plates of plywood are good reflectors of sound. On the other hand, clothing and porous materials, cork and thermocole are bad reflectors. They absorb most of the sound striking them.

The walls, ceiling and floor of a good auditorium and cinema hall are covered by absorbing materials. So there is very little reflection of sound waves and the audience hear the sound coming only from its source but not the reflected sound.

But the most wonderful example of 'hunting by ear' is provided by the bats. Bats are so specialized that they would starve to death if they should accidentally — or experimentally — lose their sense of hearing. The bat does not even rely on the noises its prey produces, as the robin and the owl do ; instead it actively sounds them out, literally, by means of an acoustic sonar. I have illustrated this in Fig. 8.7.

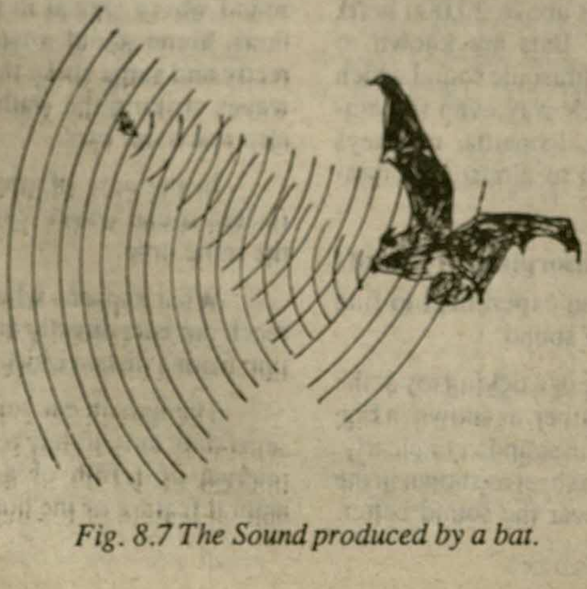


Fig. 8.7 The Sound produced by a bat.

The bat produces sounds of very high pitch, so high that the human ear cannot hear them (but the bat does hear them very well). When there happens to be an insect — the exclusive diet of our most common bats — nearby, the sound waves bounce back from the insect and travel in reverse to the bat's ears. This *reflected sound* not only tells the bat that there is something edible around, it also tells him where it is, by a complex mechanism that makes use of the fact that the ear nearer the bug receives the reflected sounds first. Thus, in the drawing, the right ear of the bat gets the reflected sound waves before the left ear does. The bat then knows that the bug is somewhat to the right. Apart from the fact that bats hunt in the dark, where eyesight would not do them much good anyhow, they turn out to be indeed very nearly blind. So they are forced to use the same sonar technique to avoid obstacles and other dangers. But how does the bat know what is edible and should be pursued, and what is dangerous and should be avoided ? Apparently sonar not only tells the bat about the presence and location of something, but also about its size, shape and other properties.

8.8 The Human Ear

Ear is a sensory organ for hearing in human beings. We can get an idea about our ear by looking at Fig. 8.8. We notice that sound travels through the outer ear and the ear canal to vibrate the small thin sheet (membrane), called ear drum. To understand the role of the middle ear and the inner ear we can take the help of the schematic diagram of the ear shown in Fig. 8.9.

A number of linked-up bones and canal lie between the ear drum and the nerves connected to the brain. All these parts carry the vibrations created by the sound in the ear drum to the auditory nerve. This nerve, in turn, take the message to the brain.

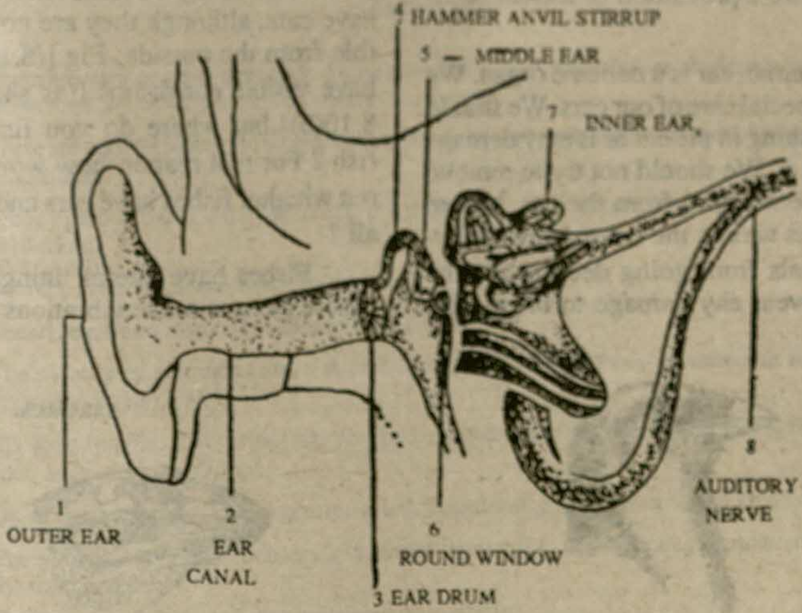


Fig.8.8 A cut view of the human ear giving the inside details.

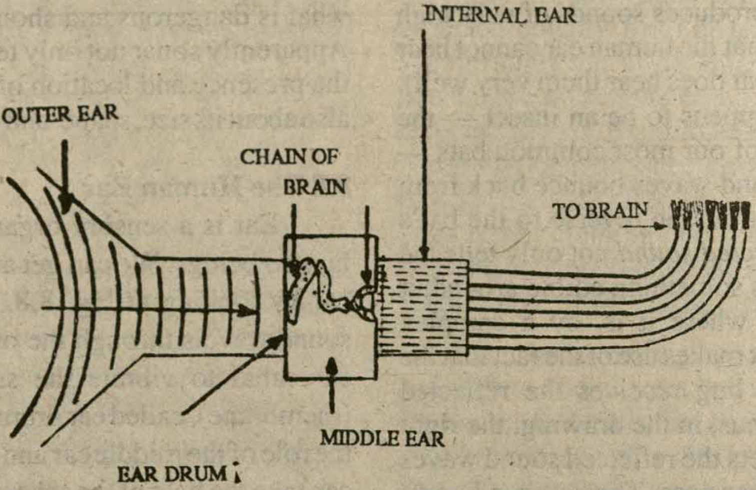


Fig. 8.9 A schematic diagram showing the action of sound in the human ear.

Ear drum vibrates in a manner similar to that of the source of sound.

The tube connected to the throat is filled with air. It helps to regulate the air pressure on the ear drums and thus protects it from any damage due to very loud sounds.

Is nature's protection of the ear sufficient ?

The human ear is a delicate organ. We must take special care of our ears. We should not put anything in the ear as it may damage the drum in it. We should not try to remove the wax-like material from the ear. Nature provides this wax to the ear to prevent foreign materials from going deep inside the ear. To prevent any damage to the middle ear, we should not blow the nose hard.

8.9 Animals Hear Sound through Sensory Organs

So far, we have read only about human hearing. Animals such as cats and dogs obviously have sensory organs (ears) and just as obviously do hear with them. Birds have ears, although they are not easily visible from the outside; Fig [(8.10 (a)] frogs have visible ear drums [(as shown in Fig. 8.10(b)],but where do you find ears in a fish ? For that matter, how would you find out whether fishes have ears and can hear at all ?

Fishes have lateral linings and these enable them to sense vibrations in water.

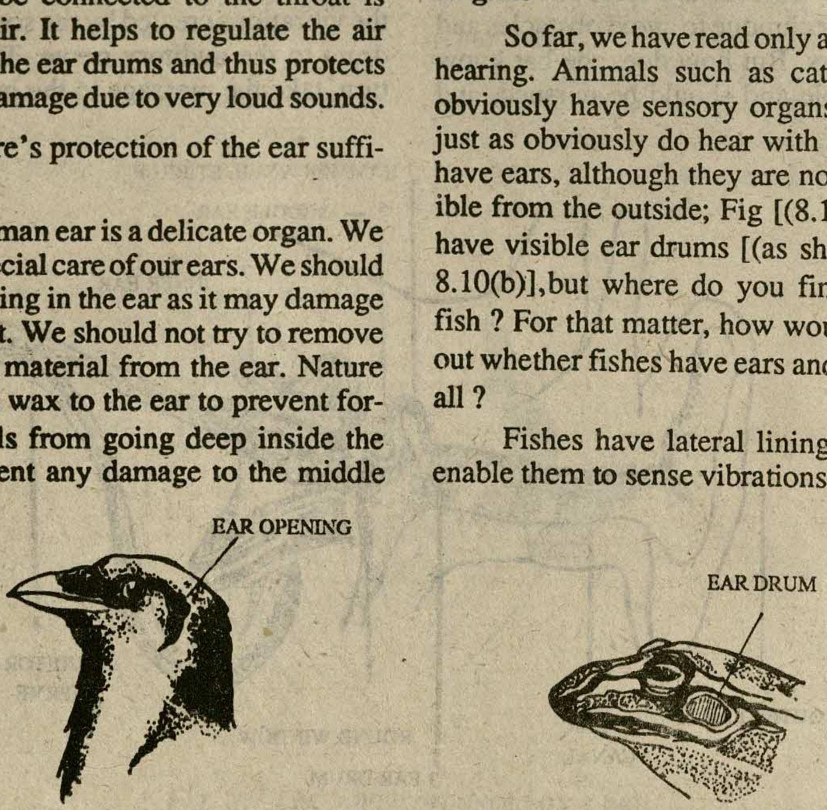


Fig.8.10

8.10 Noise

A sound which is not pleasing to the ear is classed as a noise such as produced during the explosion of a mixture of hydrogen and oxygen or by clapping two blocks of wood together or by breaking glassware on the ground etc. Modern civilization has given us various sources of noise *viz.*, type-writers, traffic on roads, horn of a motor car, running machines in big factories, beating of a drum, tap of a hammer or rattling of a train etc.

Very loud sounds (noises) cause painful sensation to the ear and hence affect the power of hearing. Noise pollution may even cause nervous disorder and mental depression. Thus, noise pollution can be a great health hazard. It is, therefore, necessary to control or minimise noise pollution. For example silencers should be used in automobiles. Blowing of horns of cars should be restricted. The volume of stereo system, of radio or that of loudspeaker should be kept low.

It has been found that air borne sound of frequency below 500 hertz cannot be eliminated without affecting ventilation. It can be reduced considerably by using felt baffles in ventilators. Noise from machinery can be reduced by arranging for its smooth running so as to avoid the production of sound by friction between its parts and by mounting the machinery in absorbent material, whenever possible. Typewriters may be placed on sound-absorbent pads. A good deal of sound may be absorbed by the use of curtains near the machinery or double walled fibre board doors for the sitting compartment. The noise of footsteps can be avoided by the use of matting in passages. The sound caused by the banging of doors can be avoided by the use of rubber pads. Double walls serve as very good insulators when the space between the walls is filled with some sound absorbent.

Summary

1. There are various types of sounds. Some sounds are *loud*, some are *feeble*. Some sounds are *pleasant* or *musical* while others are *unpleasant* or *noises* .
2. There are various sources of sound. Some source may produce different types of sound under different conditions.
3. A body produces sound only when it is in a state of vibration. Sound is produced when a body is struck or plucked.
4. Sound travels in all directions from a source.
5. Sound requires a material medium for its propagation.
6. The number of vibrations made in unit time by a sounding body is known as its frequency. It is measured in *hertz (Hz)* .
7. The sound produced by various vibrating bodies are distinguished from each other by their characteristics such as *loudness* and *pitch* .
8. On striking a surface, sound gets reflected. Sometimes reflection of sound produces an echo.
9. Ear is the sensory organ for hearing in human beings. Ear drum vibrates in a manner similar to that of the source of sound.

   Human ear is a delicate organ and needs special care.
10. Animals hear sound through a sensory organ.

11. Noise is unpleasant and unwanted sound and hence is a source of hazards.
    Noise is harmful to the ear and also to other organs.
    It is necessary to control noise and its hazards.

Questions

(A) Objective Type Questions :

1. Fill in the blanks :
   - (*a*) Buzzing of a bee is a ....sound while roaring of a lion is a .... sound.
   - (*b*) Sound is produced by a body only when it is........................
   - (*c*) The natural source of sound is...
   - (*d*) ....is a sensory organ for hearing in human beings.
   - (*e*) Thundering of a cloud is a sound which is not .... to the ear and is classed as a ....

2. State whether the following statements are true (T) or false (F) :
   - (*i*) Animals do not have any sensory organ.
   - (*ii*) Any explosion taking place on the moon cannot be heard on the earth.
   - (*iii*) Sounds originate from vibrating bodies.
   - (*iv*) The sound caused by the banging of doors can be avoided by the use of rubber pads.
   - (*v*) Sound cannot be reflected in the same way as light.
   - (*vi*) Sound can be heard by humans when the vibrations are transmitted to the inner ear *via* bone.

3. Which one of the following is *not* an example of unpleasant sound :
   - (*i*) rattling of a train
   - (*ii*) playing a flute
   - (*iii*) banging of a door
   - (*iv*) exploding a cracker
   - (*v*) thinning a metal sheet with a hammer.

4. Fill in the blanks :
   - (*i*) The maximum displacement of an oscillating object is called the ....
   - (*ii*) The number of oscillations made by the object is called the........................
   - (*iii*) The loudness of sound is decided by the ....of vibration.
   - (*iv*) We hear sound only if its frequency is greater than .... and lower than......................
   - (*v*) A taut membrane produces sound of .... frequency than a loose one.
   - (*vi*) Sound travels.......................in wood than in air.

(B) Very Short Answer Type of Questions :

1. What type of sound is produced when an empty test tube is blown with the mouth ?
2. Give an example of source of sound with very low frequency.
3. Give an example of source of sound with very high frequency.
4. Can sound be passed from the Earth to the Mars ?
5. What is an echo ?
6. Name two feeble sounds.
7. Name two pleasant sounds.
8. Name two sources that produce noise.
9. What happens when the string of a *sitar* is plucked ?
10. Name two surfaces which are good reflectors of sound.
11. What is the audible range of frequency for the normal human ear ?
12. Give two harmful effects of noise pollution.
13. Name three main parts of the human ear.

(C) Short Answer Type and Essay Type Questions :

1. What is sound ? How is it produced ?
2. Give an experiment to demonstrate that a material medium is necessary for the propagation of sound.
3. How does the sound produced by a referee's whistle differ from that produced by a violin ?
4. What is the unit of frequency of a vibrating body ? Do all vibrating bodies produce sound ? Does sound travel in all directions ?
5. (*a*) What is meant by an echo ?
   (*b*) What are the conditions necessary for its production ?
6. Give two practical applications of the use of echoes.
7. Explain the difference *in effect* when a sound is produced, first in a heavily curtained room and then in a room which has plaster walls.
8. (*a*) How do we hear ?
   (*b*) What is the internal structure of human ear ?
   What human ear needs a special care ?
9. Why a bell ringing inside a vacuum chamber cannot be heard on the outside ?
10. What is a noise ? How is it harmful and how can it be controlled ?
11. Do animals hear sound ? How ? Give two examples.

12. Why is it difficult to hear a person speaking in the open air ? Why is he heard distinctly when he uses a hollow cone with the apex at his mouth ?

13. What is the difference between a musical sound and a noise ? Classify the following sounds under the two headings 'Musical Sound' and 'Noise' :
    (*a*) Sound produced by a piano
    (*b*) Sound produced by explosions
    (*c*) Sound produced by banging pieces of wood together
    (*d*) Sound produced when a flute is played
    (*e*) Sound produced by clapping hands
    (*f*) Sound produced by several people talking together.

14. Explain why a person listening near one end of a long iron pipe hears two distinct sounds when the other end is struck with a hammer.

15. Pendulum A makes 20 oscillations in 5 seconds and pendulum B makes 10 oscillations in 3 seconds. Which has a higher frequency ? Express the frequency of each pendulum in hertz.

16. The frequency of a vibration is the inverse of its time period. What is the period of a pendulum which is vibrating at 10 hertz ?

17. Why do we not hear the screams of a bat ?

18. If you want to hear a tram approaching from far away, why is it more convenient to put the ears to the track ?

19. One whale says something to its friend 80 km away. How long will it be before the friend can hear this ? Speed of sound in sea water is 1500 m/s.

20. What is the minimum distance required to produce a distinct echo ?

21. Which of the following materials will give a good echo and which would stifle or muffle sound falling on them ?

    Wood, steel, asbestos, paper, thermocole.

22. The speed of sound in water is 1500 metres per second. How far away from an under sea rock, should a deep sea diver be, so that he can hear his own echo?

23. Where would sound travel faster ? In wood or in water ?

24. List some oscillations which you see around you. Do all of these produce sound ?

25. Arrange the following sounds in increasing frequency:
    (*i*) Baby's voice (*ii*) Man's voice (*iii*) Woman's voice.

26. Why do we hear more clearly in a curtained room than in a room without curtains ?

27. Which object is vibrating when the following sounds are produced ?
    (*i*) The sound of a *sitar* or *veena*.

(*ii*) The sound of the *tabla*.
(*iii*) The sound of a school bell.
(*iv*) The buzzing of a bee or a mosquito.
(*v*) The sound of a bursting balloon.
(*vi*) The radio.

28. The deepest part of the oceans in our world is the Mariana Trench in the Pacific Ocean, and is 11,033 metres deep. If you were on a ship above this trench and send a sound signal straight down to the water, how long will it take for the echo to reach you ? Speed of sound signal in water is 1500 metres per second.

□□

CHAPTER 9

STATIC ELECTRICITY

9.1 Historical Background

It is impossible to determine when electricity was first discovered. Records show that as early as 600 B.C. the attractive properties of amber (a yellow stone) were known. Thales of Miletus (640—546 B.C.), one of the 'Seven wise men' of ancient Greece, is credited with having observed the attraction of amber. He found that, after rubbing a piece of amber with wood, the amber would mysteriously attract certain materials like bits of papers, wood and feather. This characteristic phenomenon caused confusion until 1600 A.D. when William Gilbert gave us the first theory about electricity. Gilbert is justly called the father of electricity. He is also credited with naming it as electricity, the word electricity being derived from the Greek word for amber, 'elektron'. Amber was used by these people, even as it is now, for ornamental purposes.

9.2. Electrification of Bodies by Friction

It is now a well established fact that all bodies when rubbed together acquire the attracting power and that amber is just one of a number of substances that show this property most strongly.

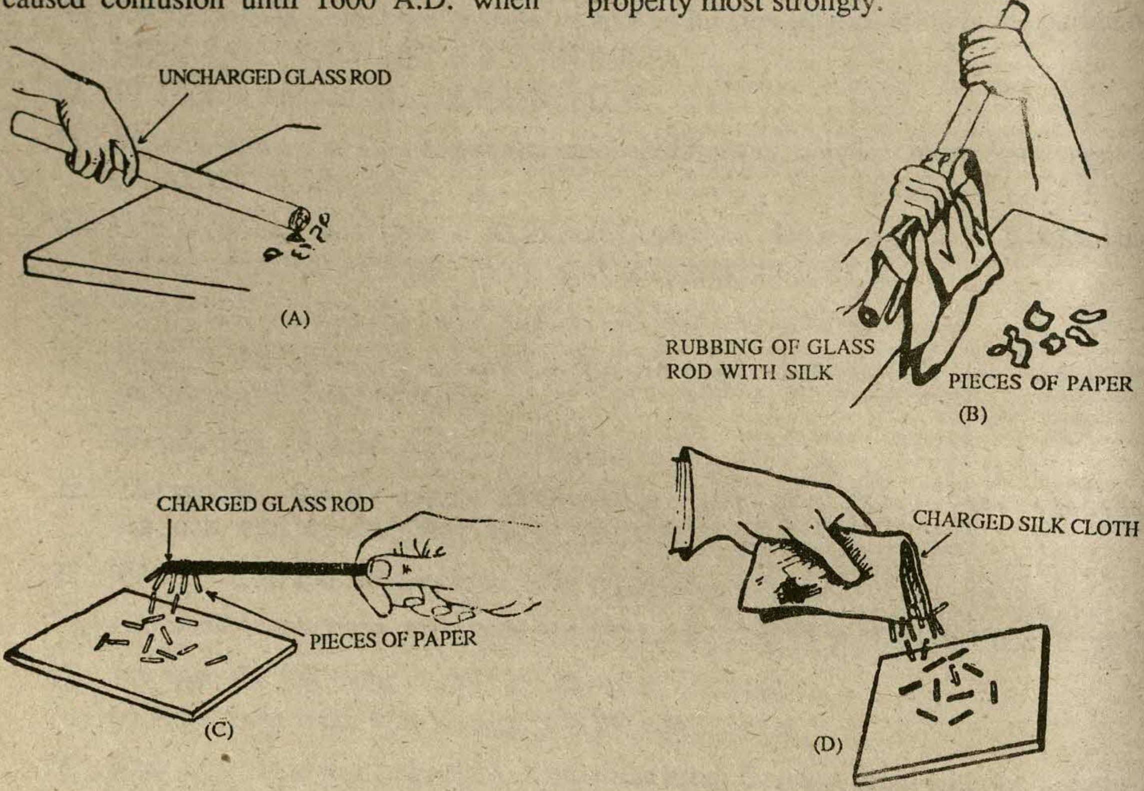


Fig.9.1 An electrically charged body attracts an uncharged body.

Have you ever noticed that when you take off a terylene shirt there is a clicking noise and that when the shirt is off it will attract bits of paper ? A similar effect can be obtained by rubbing a fountain pen on your sleeve ; it will then pick up bits of paper. A shock is sometimes experienced when you touch the door handle of an automobile after sliding over the plastic covered seat. The slight cracking sound that is heard when dry hair is brushed and the tendency of thin sheets of paper to resist separation are some of the common examples of electrification of bodies by friction.

The agency which imparts this attracting power to a substance by the process of rubbing is given the name **static electricity**. It is called static as it does not move from one point to another in a body in which it is produced. The bodies in such a state are said to be *electrified* or *charged* .

Activity :

Take a glass rod and bring it near the pieces of paper [Fig. 9.1 (*a*)]. What happens ?

Rub the glass rod briskly with a piece of silk [Fig. 9.1 (*b*)]. What happens now if you bring the rubbed glass rod near the pieces of paper ? [Fig. 9.1 (*c*)].

To get good results be sure your hands are dry and use rubber gloves.

Will the silk cloth also attract small pieces of paper after the glass rod is rubbed with it ? [Fig. 9.1(*d*)].

What does this activity prove ?

An electrically charged body attracts an uncharged body.

9.3 Two Kinds of Electric Charges :

(Interaction of charged bodies)

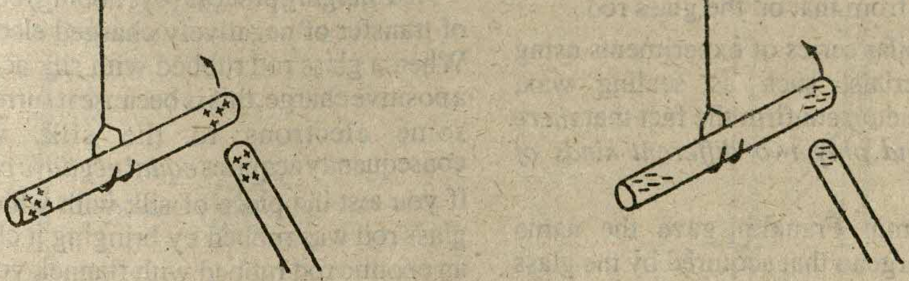
Activity :

Suspend rods of glass and ebonite in small wire stirrups as shown in Fig. 9.2.

Rub the suspended glass rod with a silk cloth. Bring the two rods near each other, but without letting them touch each other. What do you observe ?

Now rub a second glass rod with a silk cloth and bring it near the suspended glass rod, then near suspended ebonite rod. Note what happens ?

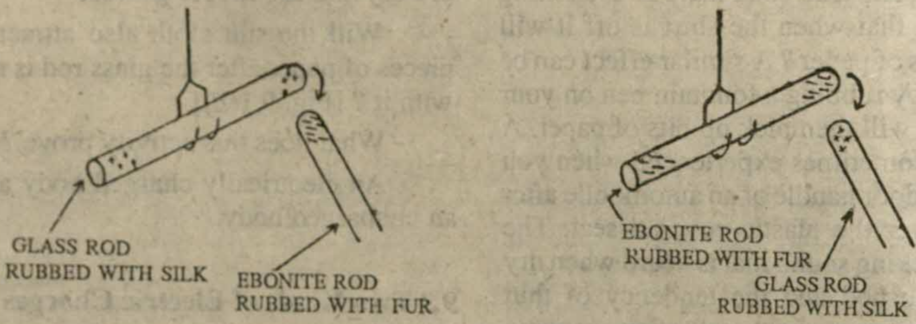
Next rub the suspended ebonite rod and the free ebonite rod with fur or flannel. Bring the free ebonite rod near the suspended ebonite rod and then near the suspended glass rod. Observe what happens.



(a) Two glass rods rubbed with silk ; the suspended rod moves away other rod is brought near it.

(b) Two ebonite rods rubbed with fur ; the suspended rod moves away when the other rod is brought near it.

Fig. 9.2 (a, b). Repulsion between charges of the same kind.



(c) The suspended glass rod moves closer to the ebonite rod.

(d) The suspended ebonite rod moves closer to the glass rod.

Fig. 9.2 (c, d). Attraction between charges of opposite kind.

How do the different free rods act on the different suspended rods ?

From these tests, what do you deduce about the types of electric charges ?

These tests show that there are two kinds of electrification or electric charge. When an ebonite rod, rubbed with fur, is brought near another rubbed ebonite rod which is suspended so that it is free to move, it is found that the two rods repel one another.

Similarly, two dry glass rods, rubbed with silk, are found to repel each other. On the other hand, a glass rod, rubbed with silk, tends to attract a rubbed ebonite rod. The charge produced on the ebonite rod, therefore, must differ from that on the glass rod.

A similar series of experiments using other materials, such as sealing wax, polystyrene etc., confirm the fact that *there are two, and only two different kinds of charge.*

Benjamin Franklin gave the name *positive* charge to that acquired by the glass rod rubbed with silk and the charge on the rubbed ebonite rod was named *negative*.

The nature of electricity developed on a particular body depends upon the nature of the material of the rubbing substance. For instance, glass when rubbed with silk, acquires positive electricity, but when rubbed with fur acquires negative electricity.

Positive charge is denoted by a *plus* (+) sign and negative charge by a *minus* (–) sign.

Not only do the above experiments indicate the existence of two kinds of electrification, but they also demonstrate a rule concerning the action of one kind of charge on another. The rule can, therefore, be stated that '*Like charges repel and unlike charges attract*'.

Charging process (by rubbing) consists of transfer of negatively charged electrons. When a glass rod rubbed with silk acquires a positive charge, this is because it surrenders some electrons to the silk, which consequently acquires *equal negative charge*. If you test the piece of silk with which the glass rod was rubbed by bringing it close to an ebonite rod rubbed with flannel, you will find the charge on the silk to be negative. Similarly the piece of flannel with which the ebonite rod is rubbed acquires positive charge. Detailed studies have shown that in each case the positive and negative charges produced by rubbing the two materials are *equal* in magnitude. *It is thus clear that the process of rubbing charges both the bodies and the charges acquired by them are opposite in nature though equal in magnitude.* The process of rubbing does not creat electric charge. It results in transferring negative charges from one material to the other. The material from which the negative charges have been transferred is left with an excess of positive charge. The material which receives the negative charges becomes negatively charged. *Thus electric charge is conserved. It can neither be created nor destroyed.*

9.4 Transfer of Charge due to Contact :

A body need not necessarily be rubbed with another to be charged. It is quite sufficient, for instance, to touch it with some other charged body.

Activity :

Take a small pith ball (pithy core of a corn cob), coat it with a metallic paint and suspend it by a silk thread as shown in Fig. 9.3

Take a ebonite rod and charge it negatively by rubbing it with flannel or fur. Hold the end of the charged rod near the pith ball, but without letting it touch the ball. What do you observe ?

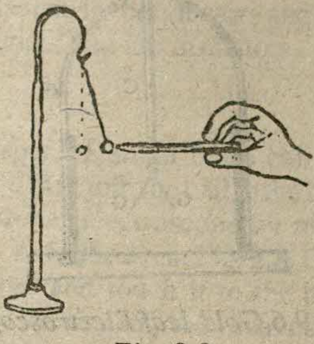


Fig. 9.3

Now allow the pith ball to come in contact with the charged rod. Note what happens.

When the negatively charged ebonite rod is brought near the pith ball, the pith ball is attracted to the rod and then having touched it, it immediately rebounds and is then repelled by the rod. We may reasonably assume that some of the negative charge has been transferred to the pith ball so that both the rod and the ball are now similarly charged.

This supposition can be proved by bringing near to the charged pith ball, a positively charged glass rod. The pith ball is attracted rather than repelled.

So from this activity we can draw the conclusion that a body can be charged due to contact with another charged body and it receives a charge similar to the charge of the body with which it was in contact.

A strip of brass or an aluminium sheet (about 8 cm × 1 cm) is bent as illustrated in Fig. 9.4 and fixed over a glass rod held in a retort stand and boss. To one side of the brass strips, a thin aluminium leaf is attached. The aluminium leaf can be cut with a razor blade into a strip about 7 cm × 1 cm.

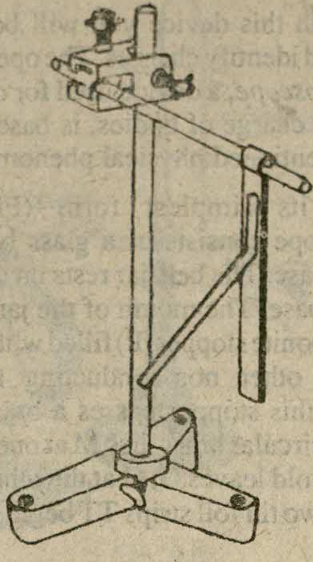


Fig. 9.4

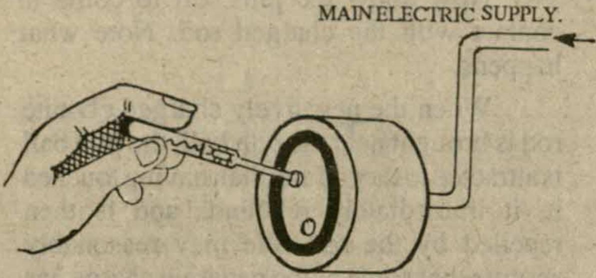

MAIN ELECTRIC SUPPLY.

Fig. 9.5

If the brass strip is touched across its edge which is on the glass rod with a charged ebonite rod, part of the negative charge will pass through the brass strip to the aluminium leaf with the result that the leaf will rise. Why does the leaf rise ?

Transfer of charge (or flow of charges) between two differently charged bodies *through direct contact* may be demonstrated by a *line tester (Fig. 9.5).*

When the lower metallic tip of the tester is made to touch the hot (or live) wire of the mains, the charges flow and the neon lamp in the tester gets lighted up.

9.5 Electroscope :

With this device you will be able to detect and identify charges. The operation of an *electroscope*, a device used for detecting electrical charge of bodies, is based on the above-mentioned physical phenomenon.

In its simplest form (Fig. 9.6) electroscope consists of a glass bell jar B without base. The bell-jar rests on a circular wooden base. The mouth of the jar is fitted with an ebonite stopper (P) filled with sulphur or some other non-conducting material. Through this stopper passes a brass rod C having a circular brass disc M at one end and two thin gold leaves G, G at the other end as shown. Two tin foil strips TT begin from the level of the gold leaves and pass down to the base which is also covered with a tin foil sheet. The strips are then connected to the earth. This arrangement makes the instrument more sensitive. In order to keep the air inside the electroscope dry, small vessel containing calcium chloride or a pumice stone soaked in strong sulphuric acid is placed inside the instrument. This avoids the leakage of charge from the gold leaves.

Fig. 9.7 shows a different design of the electroscope, in which there is a metallic knob at the upper end of a metal stem. A thin strip of gold leaf is fastened to the side of the stem. The leaves are protected by a metal case with glass observation windows. The metal stem is carefully insulated from the metal case.

To charge the gold-leaf electroscope positively, rub a glass rod with silk and touch it on to the disc of the electroscope. A positive charge is conducted to the leaves. Since both the leaves are charged with the same kind of electricity, these repel each other and diverge. The divergence of the leaves indicates the presence of an electric charge. This process of charging the electroscope is called charging by conduction.

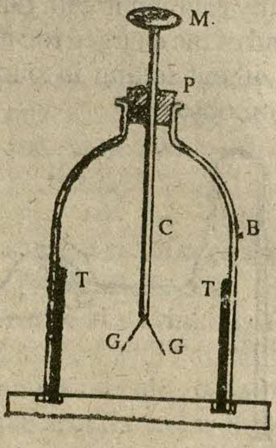


Fig. 9.6 Gold-leaf Electroscope.

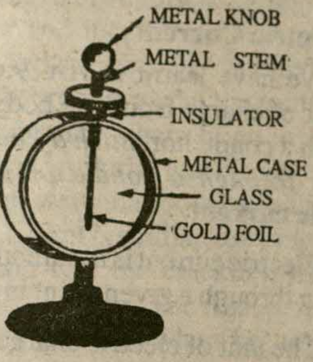


Fig. 9.7

To charge the gold-leaf electroscope negatively, touch the disc with an ebonite rod rubbed with fur.

If the divergence of leaves is very large, these will touch the tin foils which conduct away the charge to the earth and the leaves then collapse.

9.6 Conductors and Insulators :

Not everything allows electric charge to pass through it easily. Some materials allow electric charge to pass through them easily, others do not. The materials that allow electricity to flow through them easily are known as *conductors*. Those through which it is difficult for electric charge to flow are known as *insulators* or non-conductors.

Let us test and see which are the materials that are conductors and which are the materials that are insulators.

Activity :

Suspend a small brass ball by a silk thread and then join the ball to the brass knob of a gold-leaf electroscope by means of a copper wire as shown in Fig. 9.8. Charge the ebonite rod and touch it to the brass ball. What happens to the leaves of the electroscope ?

Now substitute a silk thread for copper wire. Charge the ebonite rod again and touch it to the brass ball. What happens now ?

In the first case using copper wire, the leaves of the electroscope diverge. Apparently the charge on the brass ball is transferred to the electroscope by the copper wire. In the second case when the silk thread is substituted for the copper wire, the leaves of the electroscope do not diverge because the charge has not been transferred to the electroscope by the silk.

Repeat the experiment using a number of substances. Separate them into conductors and insulators.

Most metals are good conductors. At normal temperatures, *silver* is the best conductor ; *copper* and *aluminium* follow in that order. *Graphite*, *the human body* and certain solutions are good conductors also. Mercury is the best liquid conductor.

Good insulators are silk, paraffin wax, glass, dry air, mica, hard rubber, bakelite and many plastics ; porcelain insulators for power line ; cotton ; wood ; felt etc.

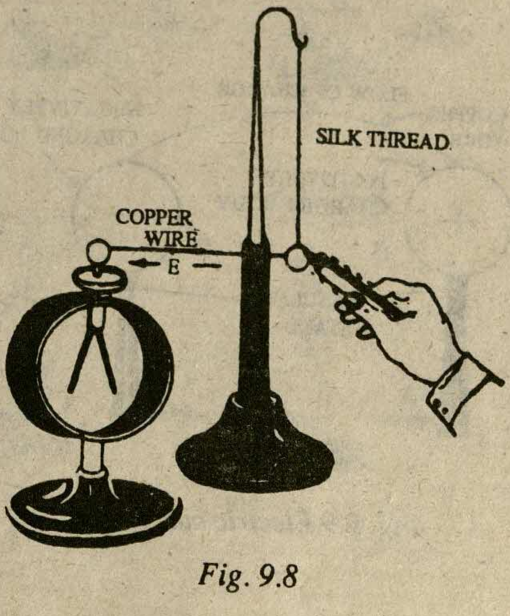


Fig. 9.8

Conductivity and insulation of a certain material is a relative term. There is no substance which is a perfect insulator. There are certain substances whose property of carrying charges lies between conductors and insulators. Such substances are cotton, wood, paper, etc.

Telegraph and telephone wires are made of hard-drawn copper as they are good conductors. These wires are placed on inverted cups of porcelain which are insulators and thus avoid the leakage of charge through poles.

Copper wire in electrical wiring at home is used as it is a good conductor.

A good conductor contains a large number of free electrons and if such a material is brought into contact with a charged body, a transfer of charge takes place. An insulator has few free electrons because even the outermost electrons are rather firmly held within the atomic structure. Thus, the transfer of charge through an insulator is usually negligible.

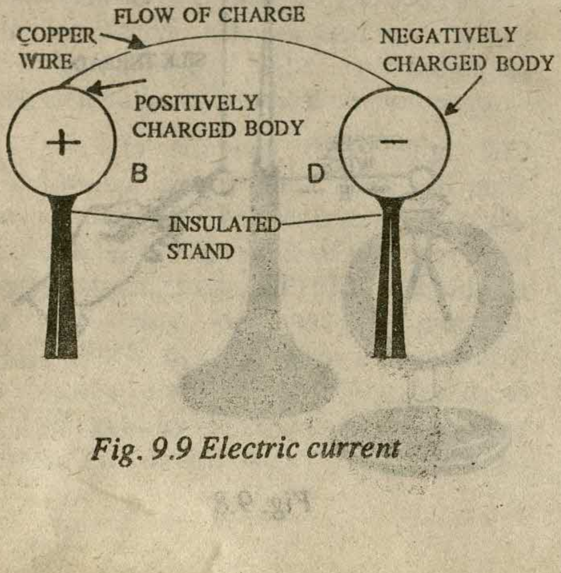


Fig. 9.9 Electric current

9.7 Electric Current

We have learnt in Art. 9.6 about the transfer of charge from one body to another through a conductor. *Such a flow of electric charge through a conductor is called an* **electric current.**

Electric current is the amount of charge passing through a given point in one second.

The unit of electric charge is *coulomb* (C) whereas the unit of electric current is *ampere* (A).

You will learn the definitions of these units in higher classes :

$$1 \text{ ampere} = \frac{1 \text{ coulomb}}{1 \text{ second}}$$

$$1 \text{ milli ampere (mA)} = \frac{1}{1000} \text{ A}$$

$$= 0.001 \text{ A}$$

$$1 \text{ micro-ampere } (\mu\text{A}) = 10^{-6} \text{A}$$

$$= 0.000001 \text{ A}$$

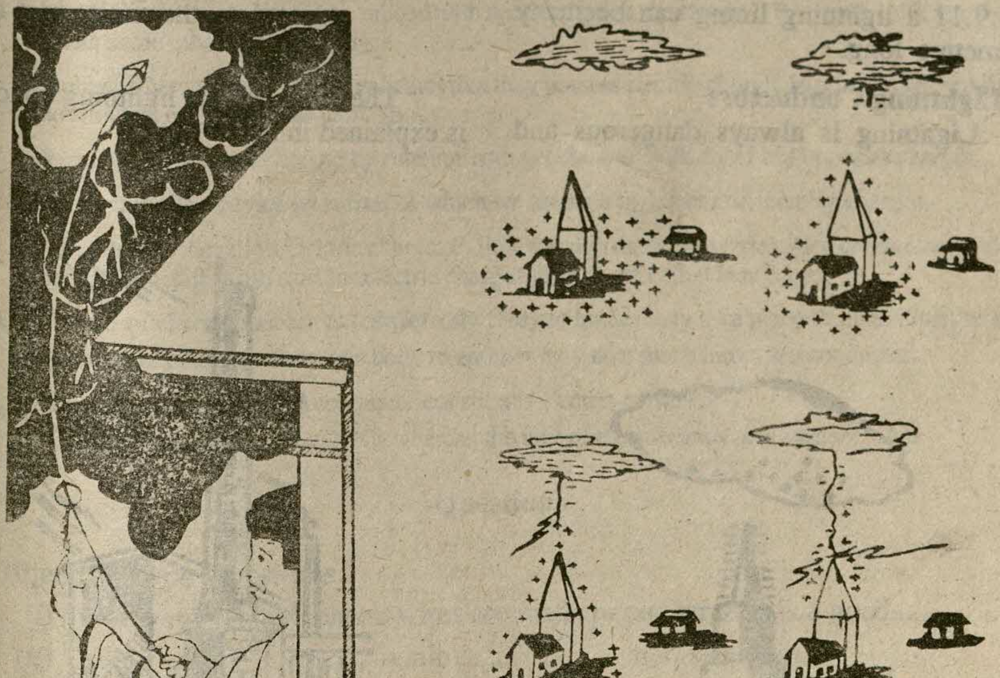
By convention charge flows from B to D. Actually electrons flow from D to B.

9.8 Electrical Phenomena in the Atmosphere

The occurrence of lightning and thunderstorm has been known to man for a very long time. These natural phenomena were the cause of much speculation about their origin and nature. In 1748, Nolled, a French scientist, noted a number of similarities between electricity and lightning and expressed his views that they were different aspects of the same phenomena. It was left to Benjamin Franklin who, in 1750, established the complete identity of lightning flash and the electric spark. He devised an experiment in which he allowed a spark discharge to pass between two highly charged plates. He found that this discharge resembled the lightning and its path was zig-zag. He killed a hen and struck a pigeon blind by an electric discharge just as the lightning flash kills men and strikes them blind in nature. Other points of similarity that Franklin listed between them were that both gave light, the colour of their light is similar, their motion is very swift and that the crackling noise is produced in both cases. The final proof was given by him in 1752 when he collected electricity from a cloud. During a thunderstorm, he flew a kite which had projecting from it a sharp pointed wire in a field near Philadelphia. The kite was flown with an ordinary string and to the other end of the string was attached a key separated from the observer by a silk thread. The silk thread was fixed to a tree. As soon as a charged cloud came over the kite and thread made wet by the rain, electricity flowed from the thread to the key. When he put his hand near the key, a spark jumped to his fingers.

Franklin showed that clouds and the Earth store electricity. The lightning was the discharging.

When the thunder clouds with unlike charges approach each other, a powerful electric field is set up between them. Under its effect the electrons start moving from the negatively charged thundercloud across the air, which becomes a rather good conductor. As a result a lightning flash occurs between the two charged clouds. The discharge lasts for about $\frac{1}{10000}$ th of a second. Rapid and energetic expansion of the heated layers of air produce sound waves which we hear as thunder claps.



(a) (b)

Fig. 9.10

Lightning and thunder occur simultaneously but we usually hear the clap of thunder after we have seen the flash of lightning. This is due to the fact that sound in the air propagates with a speed of 330 m/sec and light propagates with a speed of 300,000,000 m/sec.

An electric discharge lightning can occur not only between two clouds but also between a charged cloud and the Earth.

When, for instance, a negatively charged cloud comes sufficiently close to the Earth, it induces, particularly on high ground, a powerful positive charge directly underneath. As the cloud moves, the area of positive charge underneath it moves. More often a stroke of lightning takes place between the cloud and the Earth. As is clear from the Fig. 9.11 a lightning lining can be many kilometres long.

9.9 Lightning Conductors

Lightning is always dangerous and unpredictable. It can split a tree and very often it is the cause of fires if it strikes a building.

A lightning conductor is a protective device fitted to tall buildings and to other installations. It consists of three essential parts :

(*i*) A rod made of copper or galvanised iron raised above the highest point of the building. It ends into a large number of sharp points.

(*ii*) A conductor connecting the rod with the ground. It is generally a copper or an iron strip.

(*iii*) The earth connection. The lower end of the strip carries a big metal plate which is buried deep into the moist part of the earth.

The action of the lightning conductor is explained in two ways.

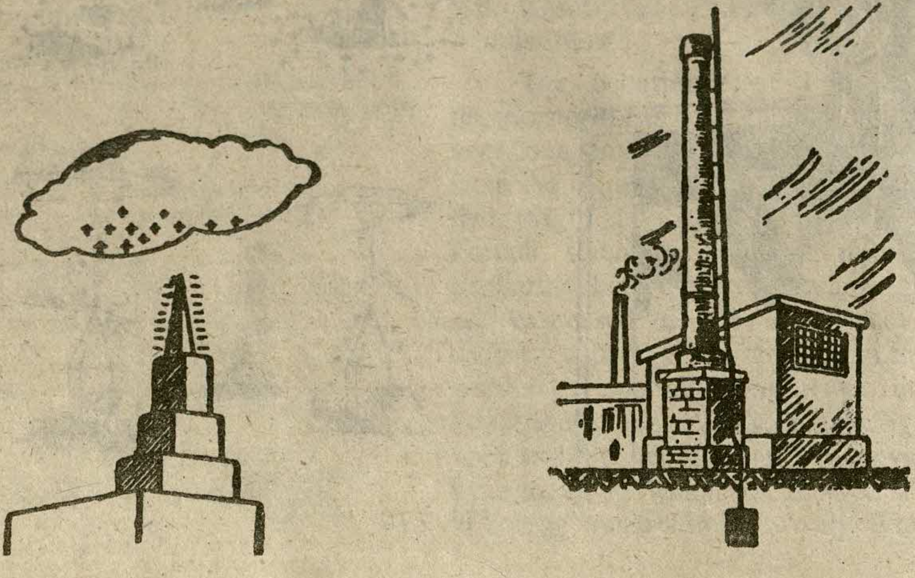


Fig. 9.11 Lightning Conductor

During a thunderstorm, a charged cloud passes above the points of the lightning conductor. If the cloud is positively charged, it induces negative charges on its upper end [Fig. 9.11]. These negative charges become so tightly packed that they ionize the air surrounding them. Repelled by the negative charges left behind in the conductor and attracted by the positive charges in the cloud, air molecules are free to move up towards the cloud. The charged molecules form an 'invisible' wind which allows charge to leak away from the building or Earth. If the wind reaches the cloud, it neutralizes the positive charge there and stops it coming down from the cloud in a flash of lightning.

If a discharge actually takes place, the lightning conductor provides an easy passage to the charge from the cloud to the Earth. The building is thus saved from the destructive effects of this lightning.

Summary

1. All bodies when rubbed together are said to be *charged* or *electrified.*
2. There are two and only two different kinds of charges — *positive* and *negative.*
3. An electrically charged body attracts an uncharged body.
4. Like charges repel and unlike charges attract.
5. A body need not necessarily be rubbed with another body to be charged. It is quite sufficient to touch it with some other charged body.
6. Repulsion between two bodies indicates that they possess electric charge. In other words repulsion is the sure test of electrification of a body.
7. When two bodies are charged by rubbing both get charged with equal but opposite charges.
8. Electroscope is a device by means of which we are able to detect and identify charges.
9. The materials that allow electric charges to flow through them easily are called *conductors* and those through which it is difficult for electric charges to flow are called *insulators.*
10. Transfer of charge between two differently charged bodies may take place through direct contact. The transfer of charge from one body to another may take place through a conductor.
11. Flow of charges through a conductor constitutes electric current. The unit of charge is *coulomb* (C) whereas the unit of electric current is *ampere* (A).

Questions

(A) Objective Type Questions:

(*i*) Telegraph and telephone wires are made of copper as it is a good..................

(*ii*) Like charges .... while .... charges attract.

(*iii*) When a glass rod is rubbed with silk it acquires a .... charge while an ebonite rod when rubbed with flannel acquires a .... charge.

(*iv*) A .... is a material through which an electric charge is readily transferred.

(*v*) Mica is a good ....

(*vi*) Two ebonite rods rubbed with wool .... each other.

(*vii*) An ebonite rod rubbed with wool .... a glass rod rubbed with silk.

(*viii*) Two objects rubbed against each other will .... each other.

2. Write 'T' against the sentences which are true and 'F' against the sentences which are false in the following statements :

(*a*) All bodies when rubbed together are said to be charged or electrified.

(*b*) Copper and silver allow electric charges to flow through them easily and hence are called insulators.

(*c*) Positive charges repel each other.

(*d*) Flow of electrons (which are negatively charged particles) through a conductor is called an electric current.

(*e*) When two bodies are charged by rubbing both get charged with equal but same charged.

3. Choose the correct answer :

When a polythene strip is rubbed with a duster (*i.e.*, a piece of cloth), it acquires a negative charge. Hold it very near a small pith ball which is coated with a metallic paint and suspended by a silk thread. The pith ball comes in contact with the charged strip.

(*i*) The pithball acquires a negative charge and gets repelled.

(*ii*) The pithball acquires a negative charge and gets attracted.

(*iii*) The pithball acquires a positive charge and gets attracted.

(*iv*) The pithball acquires a positive charge and gets repelled.

(B) Very Short Answer Type Questions :

1. What kind of charge is acquired by a silk cloth when a glass rod is briskly rubbed with it ?
2. Name the two kinds of electric charges that are found in nature.
3. Give three examples of conductors of electricity.
4. Give three examples of insulators.
5. Name the unit of electric current.
6. Name the unit of electric charge.
7. What would happen if two positively charged freely suspended bodies are brought very near to each other ?
8. Name the kind of charge that an ebonite rod acquires when it is rubbed with a piece of flannel.

9. What kind of charge is acquired by a neutral object when it touches a positively charged object ?

10. What are insulators ?

(C) Short Answer Type and Essay Type Questions :

1. Three rods — copper rod, plastic rod and glass rod — have been rubbed with a silk cloth. Which rod or rods will be left with an electric charge ?

2. Which way would you expect the suspended rod to move in Fig. 9.12 ?

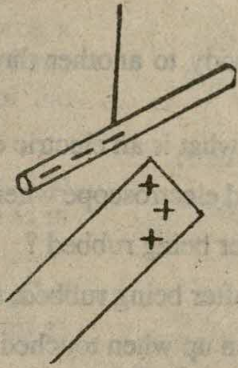


Fig. 9.12

3. Why can an ebonite rod be charged by rubbing while holding it in the hand but a metal rod cannot ?

4. It is found that an object A repels object B, A attracts C and E repels D. If you know that D is positively charged, what kind of charge does B have ?

5. What will happen if you touch together the knobs of two identically and equally charged electroscopes :
   (*a*) if both are positively charged ?
   (*b*) if both are negatively charged ?
   (*c*) if one is negatively charged and the other is positively charged ?

6. Distinguish between conductors and insulators giving *four* examples of each.

7. A gold leaf electroscope is used for detecting electric charge. Why do the gold leaves of the electroscope fly apart when a charged body is placed on the brass disc of the electroscope ?

8. How would you demonstrate that
   (*a*) there are two distinct kinds of electric charges, and
   (*b*) like charges repel each other and unlike charges attract each other.

9. Arrange the following materials in order starting with the best conductor and ending with the best insulator :

   Copper, silver, salt water, oil , aluminium, tungsten, glass, rubber, cotton.

10. How can you show by an experiment that when two bodies are charged by rubbing both get charged with equal but opposite charges ?
11. Describe an experiment to demonstrate that repulsion between two bodies is the only test that indicates that they possess electric charge.
12. Define an electric current. Name the device used by electricians to test the flow of charges in homes and factories.
13. How will you show experimentally that an electrically charged body attracts an uncharged body ?
14. Can charge flow from one body to another through a conductor ? How will you demonstrate it ?
15. What is static electricity and what is an electric current ?
16. What will happen to a charged electroscope when you touch its disc or cup ? Why ?
17. Do all bodies get charged after being rubbed ?
18. Why does a rubber balloon, after being rubbed, stick on to a wall ?
19. Why does the paper strip open up when touched with a charged rod ?
20. How does a lightning conductor work ?

□□

CHAPTER 10

ENERGY

10.1 Energy :

You have learnt in Class VI that the work done on a body depends on the magnitude of the force and the distance through which the body moves due to the applied force.

Work done = magnitude of force x distance moved by force in the direction of the force.

If the force is measured in *newton* and the distance in *metre*, the work done is in **joule.**

Capacity of a body to do work is called **energy.** It is measured in the same unit as work *i.e., joule.*

When we say that something has energy, we mean that it is capable of exerting a force on something else and doing work on it. On the other hand, when we do work on something, we have added to it an amount of energy equal to the work done. What properties can a body have that may be converted into work ? In other words, what forms does energy take ?

10.2 Forms of Energy (Mechanical Energy)

Energy enables work to be done and people and machines need a supply of it. Experience shows that energy exists in many different forms.

When the energy is due to the motion of a body, it is called ***kinetic energy*** (K.E.).

Any moving body possesses kinetic energy and the faster it moves the more kinetic energy it has.

Examples :

(*i*) A running train

(*ii*) Moving air

(*iii*) A moving hammer

(*iv*) A fast moving cricket ball on the cricket ground

(*v*) Very fast moving electrons in a television tube

(*vi*) Running water

(*vii*) A fast moving bullet when it is fired from a rifle

(*viii*) A moving boat in water.

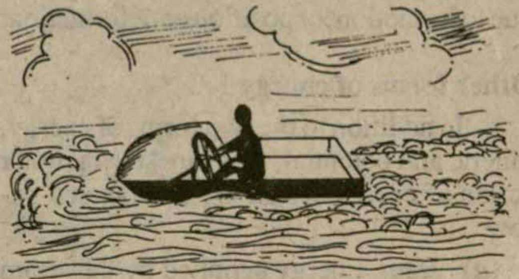


Fig. 10.1 Kinetic Energy of a moving boat

Kinetic energy of a body depends upon (*i*) the mass of the body, and (*ii*) the velocity of the body.

The energy possessed by a body by virtue of its position or condition is called its ***potential energy*** (P.E.).

Potential energy gets stored in a body when it is *deformed i.e., stretched, wound, twisted, or compressed.*

Examples :

(*i*) A stretched bow with an arrow (Fig. 10.2)

(*ii*) Water at the top of a water fall

(*iii*) A stretched rubber band in a catapult. (Fig. 10.3)

(*iv*) Water in a mountain reservoir

(*v*) Wound up watch springs

(*vi*) Stretched elastic bands

(*vii*) Compressed spring in a toy gun.

Food and fuels like coal, oil and gas are stores of *chemical energy*. The energy of food is released by chemical reactions in our bodies. Fuels release their energy when they are burnt (a chemical reaction) in an engine or other device. A car engine uses chemical energy. *Chemical energy is a form of potential energy.*

Kinetic energy and potential energy taken together are called ***mechanical energy.*** Thus mechanical energy of a body may be due to its motion, or position or deformation.

Other forms of energy :

In addition to the two forms of energy, kinetic and potential, there are several other forms of energy which are enumerated below :

(*a*) *Heat*. Energy supplied by the steam or oil engines is obtained from heat.

(*b*) *Light*. In photography light energy supplies the necessary chemical energy for the process.

(*c*) *Sound*. It is definitely a form of energy as glass panes of doors and windows of buildings in the vicinity of a big explosion are known to be shattered to pieces on account of the effect of the sound.

(*d*) *Magnetic*. A piece of iron when attracted by a magnet moves towards it and motion is the result of magnetic energy.

(*e*) *Electricity :*

Static electricity. Motion of electrified bodies is the result of attraction or repulsion due to electric charges residing on the bodies.

Current electricity. Working of electric trains, trams, heater, lighting bulbs and motors is due to the energy supplied by electric current.

(*f*) *Chemical*. Heat and mechanical energy produced by explosives are supplied by chemical energy possessed by the chemicals used in them. Food and fuels store chemcial energy.

(*g*) *Molecular energy*

(*h*) *Nuclear energy*

(*i*) *Radiant energy*

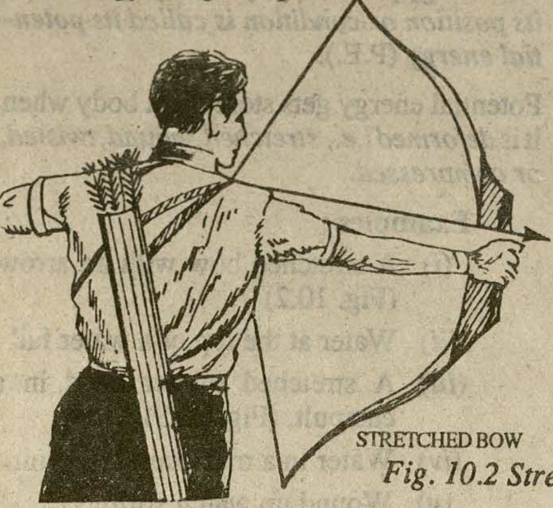


Fig. 10.2 Stretched bow

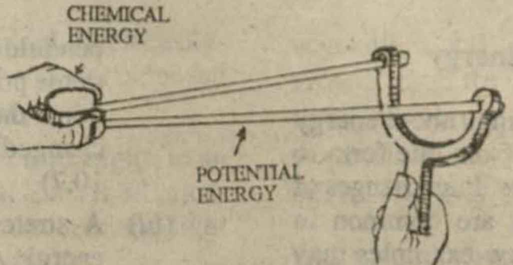


Fig. 10.3 Stretched Rubber band

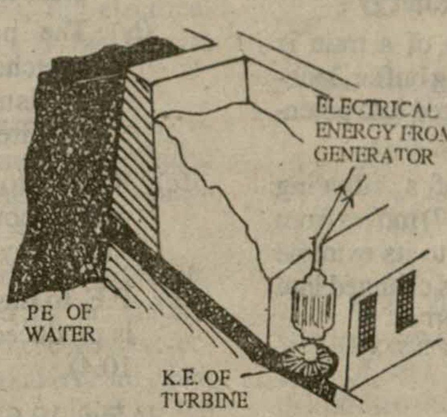


Fig. 10.4.

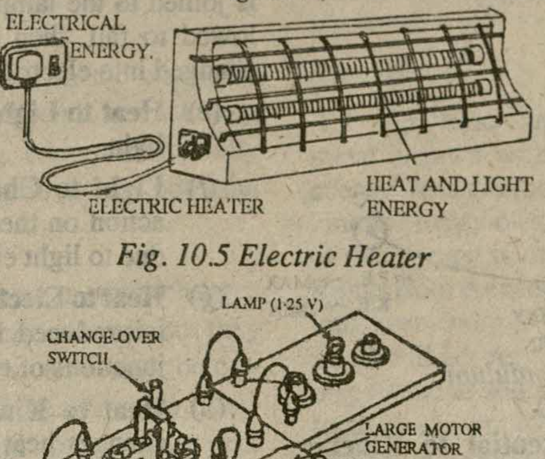


Fig. 10.5 Electric Heater

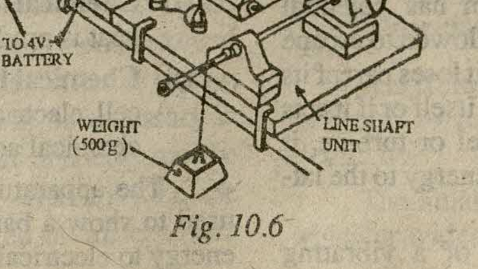


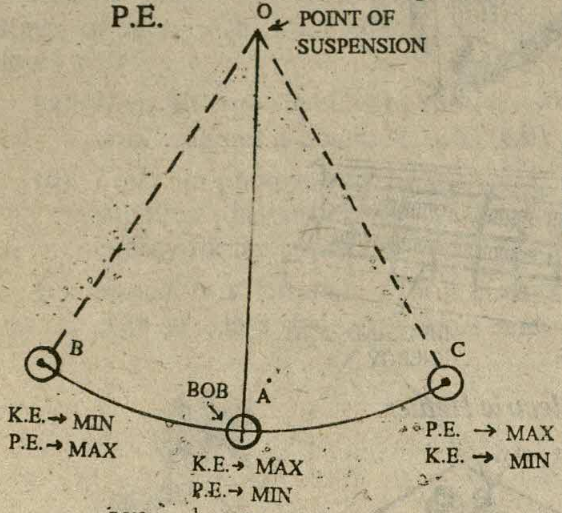
Fig. 10.6

10.3 Tansformation of Energy

One of the useful things about energy is that it can be changed from one form to another by suitable devices. Interchanges of various forms of energy are common in nature and industry. A few examples may briefly be stated here.

(*a*) **Kinetic to Potential Energy :**

- (*i*) When the motion of a train is checked by a spring buffer, kinetic energy is changed into potential energy.
- (*ii*) When the bob of a vibrating pendulum (Fig.10.7) moves from its mean position to its extreme position, its K.E. is changed into P.E.



Vibrating Pendulum
Fig. 10.7

(*b*) **Change of Potential to Kinetic Energy :**

- (*i*) Water in a dam has potential energy. When allowed to escape to a lower level, it loses part of its potential energy itself or if it acts on a water-wheel or turbine, it imparts kinetic energy to the latter.
- (*ii*) When the bob of a vibrating pendulum moves from the extreme position to the mean position, the potential energy is changed into kinetic energy (Fig. 10.7).
- (*iii*) A stretched bow has potential energy. As it unbends, it loses its potential energy and the arrow gains kinetic energy (Fig. 10.2).
- (*iv*) The potential energy of the stretched rubber band in a catapult is used to throw a stone which acquires K.E. (Fig. 10.3).

(*c*) **Kinetic to Heat.** Heat is produced when a moving wheel of an engine is stopped by applying brakes.

(*d*) **P.E. to Electrical.** Electrical energy is produced by water turbines (Fig. 10.4).

In Fig. 10.6 if the change over switch is joined to the lamp and the weight is allowed to fall, then P.E. of the weight is changed into electrical energy.

(*e*) **Heat to Light.** A red hot ball emits light.

(*f*) **Light to Chemical.** The chemical action on the photographic plate is due to light energy.

(*g*) **Heat to Electricity.** Electric current is produced by heating one of the junctions of two dissimilar metals.

(*h*) **Heat to Kinetic.** A steam engine changes heat energy to kinetic energy.

(*i*) **Chemical to Heat.** When coal burns, heat is produced.

(*j*) **Chemical to Electrical.** In a voltaic cell, electric current is produced by a chemical action.

The apparatus in Fig. 10.6 may be used to show a battery changing chemical energy to electrical energy.

(*k*) **Electric to Chemical.** In electrolysis, the electrolyte is decomposed into its constituent parts.

(*l*) **Electrical to Heat and Light.** In an electric heater and electric bulb, electric current produces heat and light respectively (Fig. 10.5).

(*m*) **Electrical to Mechanical.** In electric trams and fans, the electrical energy is changed into mechanical energy.

(*n*) **Mechanical to Electrical.** In a dynamo, electric current is produced by rotating the armature in a magnetic field (Fig. 10.4).

(*o*) **Electrical to Sound.** In electric bells, sound is produced by an electric current. A loudspeaker converts electricity in sound. Sound is heard when lightning falls from a cloud on the ground or on another cloud.

Periodic Interchanges : In the case of a vibrating body such as a pendulum, a tuning fork or a violin string, energy continually changes from the kinetic to the potential form and *vice versa*.

Complex Changes : There are some changes of energy which are very complex but they do illustrate that energy can neither be created nor destroyed and man can only transform it from one kind into another. For example, a labourer carrying bricks up a ladder is not *creating* potential energy, but is only *converting* some of his internal store of energy into another form. After a certain interval, rest and food will be necessary in order that his internal store of energy may be replenished. No matter what may be the form of food, it is derived ultimately from vegetation, and vegetation depends for its growth upon the light and heat of the sun. Hence the store of energy in the sun is responsible primarily for all the *energy* or *life* on the earth.

10.4 Law of Conservation of Energy:

The law of conservation of energy states that :

(*a*) *Energy can neither be created nor destroyed but it can only be transformed from one form into others.*

(*b*) *The total amount of energy in this universe is constant.*

In all the interchanges in the form of energy sooner or later, energy assumes the form of heat, which in due course becomes distributed throughout the space. It probably becomes unavailable, but is still there, though scattered.

Examples :

(1) What happens when a piece of metal is sawn with a hacksaw ? Chemical energy from the food we eat is changed into kinetic energy of the hacksaw blade. Some of this energy is used to separate the metal filings from the metal and some is converted into heat energy. The hacksaw blade and metal will get very hot. Some energy will be dispatched as sound. But if we take the sum total of the energy at any instant, it will always be found to be constant.

(2) Consider the energy chain for a coal-fired power station.

heat from sun → plants (trees) →Coal → steam → turbine → Coal generator → electricity.

The intial source of energy is the sun which provides the energy for the trees and plants to grow. These in turn decay and over the years form coal. When this is burnt it releases heat energy and vaporises water to form steam which in turn drives the turbine. The kinetic energy of the turbine is converted into electrical energy in the generator. Again if we take the sum total of energy at any instant, it will always be found to be the same.

(3) When we throw a stone upward into the air, the work we do appears first as kinetic energy ; as the stone rises, the kinetic energy gradually becomes potential energy ; at its highest point, the stone has potential energy exclusively, which, as the stone begins to fall, is converted back into kinetic energy; and, when the stone strikes the ground, the kinetic energy does work. Where has the work gone ? It has been converted into heat. We can state here the general conclusion that whenever mechanical energy disappears in a system of bodies isolated from its surroundings, all the energy is converted into either work or heat.

In this case also we will find that at any instant, the total amount of energy always remains constant.

(4) The bob of a pendulum (Fig. 10.7) is raised up through a distance as it moves to the right extreme position C. Its potential energy has thus been increased. Here the bob is at rest for a moment. Therefore, it has no kinetic energy. As it comes to the mean position A, its potential energy has changed into kinetic energy. The sum total of energy would, however, be constant. The energy change takes place in the reversed direction as the bob moves to the left extreme position B. Kinetic energy is again changed into potential energy. In between the extreme position and the mean position, the energy is partially potential and partially kinetic in such a way that the sum is constant.

10.5 Different Sources of Energy :

Almost the whole of our available energy comes from the sun. Sun helps in the growth of vegetation which is the source of muscular energy in all the living beings. Sunlight acting for ages on vegetable matter has energy stored up in coal and oil, which are the main sources of our energy.

Energy of water and air is also derived from sun.

Recently atomic energy has shown a great usefulness for mankind. It is seen that when the nucleus of a heavy atom disintegrates, energy is liberated. This energy results from the conversion of matter into energy and thus a vast store of energy can be made available from the matter in the universe.

Thus the various sources of energy are

(*i*) Fossil fuels (coals and oil)

They are formed of plants or animals that decayed and got buried for a long time, thus forming great underground beds of coal and pools of oil.

(*ii*) Wind (air in motion) — Windmill.

It converts K.E. of the wind to useful work.

(*iii*) Water—hydroelectric dams.

P.E. of water is converted into K.E. of flowing stream.

(*iv*) *Sea Waves* — during high tides water is impounded to generate power. India has good potentials to build tidal power stations in Gujarat and in West Bengal.

(*v*) Sun (solar energy).

(*vi*) Waste material (cattle dung)—gobar gas.

Cattle dung has given rise to an indigenous fuel called *biogas* or *gobar gas*. The dung is fermented to yield a combustible gas methane, which can be used as a fuel and the residue can be utilized as manure.

Earth receives *solar energy* at the rate of about 1000 joule per second per metre^2 on a clear day at noon. Solar energy is used for cooking, melting, heating, etc. Solar batteries are used for space flights. Efforts are in progress throughout the world to generate electricity by using solar energy.

Fossil fuels : Coal, kerosene, petrol, diesel and natural gas are called *non-renewable* sources of energy because they take millions of years to form and once they are used up, they will not be available again.

At present natural resources of chemical energy such as coal, kerosene oil, petrol, diesel and natural gas are being used at a rapid rate. The rate of usage is likely to increase as under-developed countries become more industrialised. No doubt more reserves will be discovered and utilised although the costs of production will increase as they become less easy to tap. Nuclear power plants, which at present rely on fission, are becoming increasingly unpopular because of fears about leakage of radioactivity and the disposal of the waste products. But what are the alternative sources of energy ?

Attempts will undoubtedly be made to harness the energy which is stored in tides. The windmill, which used the kinetic energy of the winds, may return to favour in a more efficient form. Scientists all over the world are trying to make use of the energy from the sun (Solar Energy). They have been able to make cookers, water heaters and cells which work using the solar energy. Solar cells are already used to produce electricity and this is one area in which there are likely to be important new developments. A car powered by solar energy has already crossed Australia. Bio-mass which includes garbage, industrial waste, crop residue, sewage and wood is another newly developed area which is being used as a source of energy.

Water (tides), wind, sunlight and biomass are called *renewable sources* of energy since they can be used again and again. Moreover, they are freely available and do not pollute the environment. Efforts are being made to use to the maximum the energy available from them.

10.6 The Judicious Use of Energy Need Be Encouraged :

Machines such as engines used in automobiles are not very efficient because lot of energy is wasted in overcoming friction between the various parts. Similarly there is energy wastage in heating a normal house by the conventional heating system using conduction, convection and radiation. We can enumerate various other ways in which the energy is lost in undesirabe forms in devices used in everyday life. Therefore, we must appreciate that there is a need to use energy judiciously and economically, especially that from non-renewable sources of energy. Losses of energy in machines used in industry and in appliances used for domestic purposes should be minimised by their proper maintenance. The various parts of the machines and appliances should be properly and regularly *lubricated* or *oiled*. Attempts are being and will be made to improve the efficiency of machines and to cut down energy wastage. Heating a normal house is achieved for more efficiently than it was a few years ago, but there is still room for improvement.

Alcohol can also be used as a fuel in automobiles. Alcohol engines run at lower temperatures than petrol engines. Alcohol has the advantage that it can be produced from organic substances such as sugar.

"*Gasohol*" is a fuel made from a mixture of alcohol and petrol.

Where *electricity* is playing an increasing role is on the railways which are becoming more electrified. Diesel replaced coal as a fuel and electricity is now replacing diesel. This method of propulsion is more efficient and much cleaner. The atmosphere is not polluted as well.

Summary

1. Energy is defined as the capacity of a body to do work.
2. A moving object possesses kinetic energy.
3. A body raised to a certain height acquires potential energy.
4. Potential energy gets stored in a body when it is deformed *i.e.*,stretched, wound, twisted or compressed.
5. Potential and kinetic energy taken together constitute mechanical energy of a body.
6. Chemical energy is a form of potential energy.
7. Kinetic energy of a body can be converted into potential energy and *vice-versa.*
8. Mechanical energy can be converted into heat, light, sound or electric energy. Electric energy can be converted into any other form of energy.
9. Transformation of energy from any form usually takes place to more than one forms.
10. Law of Conservation of Energy states that energy can neither be created nor destroyed but the sum total of energy in this universe always remains constant. Energy can be transformed from one form into another.
11. Fossil fuels : Coal, kerosene, petrol, diesel, and natural are called non-renewable sources of energy whereas water (tides), wind, sunlight and biomass are called *renewable* sources of energy. Use of renewable sources of energy should be encouraged and that of non-renewable sources should be minimised.
12. The use of devices based on solar energy should be encouraged.
13. We must make judicious use of energy and the energy losses in mechanical devices can be minimised by lubrication and proper maintenance.
14. Electricity is now replacing diesel. This method of propulsion is more efficient and much cleaner.

Questions

(A) Objective Type Questions :

1. **Fill in the blanks :**

   (*i*) If a body is lifted above the ground, its energy............

   (*ii*) A body possessing is capable of doing............

   (*iii*) Matches, wood, coal, kerosene, diesel and petrol have .... energy stored in them.

   (*iv*) ....energy is used to run machines in factories, electric trains, lifts and flour mills.

(*v*) Cooking gas is a............fuel.

(*vi*) Wind is a............source of energy.

(*vii*) In hydel power stations the energy of...............is used.

(*viii*) A loudspeaker converts.............energy into............energy.

2. Write 'T' against those statements which are true and 'F' against those which are false :

(*a*) A labourer carrying bricks up a ladder is not creating potential energy but is only converting some of his internal store of energy into another form.

(*b*) Diesel is a renewable source of energy.

(*c*) These days the efficiency of mechanical devices can be increased without lubrication and proper maintenance.

(*d*) Water in a mountain reservoir is an example of mechanical energy.

(*e*) A piece of iron when attracted by a magnet moves towards it and the motion is the result of magnetic energy.

(*f*) A moving bullet is an example of potential energy.

3. The unit in which energy is measured is the

(*a*) watt (*b*) joule (*c*) volt (d) coulomb.

4. Fill in the blanks :

(*i*) The water stored in an overhead tank possesses............energy.

(*ii*) An aeroplane flying in the sky possesses...............and............energy.

(*iii*) Chemical energy is a form of..............energy.

(*iv*) While rolling a *chapati*...............energy of the rolling pin is used to do the work.

(*v*) Sun's radiation heats the earth. The air in turn is heated by land and rises up. In this case............energy is transformed into.................energy.

(*vi*) In a photoelectric cell,.................energy is converted into.............. energy.

(*vii*) In a cinema theatre electrical energy is transformed into .... and...............energy.

(*viii*) When you climb a tree, you use up...............energy and gain.............

(*ix*) When an athlete runs,...............energy is changed into...............energy.

(*x*) A biogas plant uses.................as the source and gives..................and...............for use.

(*xi*) ....and..............are non-renewable sources of energy.

(*xii*) The water stored in a dam is a source of...............energy.

(*xiii*) People living in...............use more energy than people living in............,.

(*xiv*) ....and..............are renewable sources of energy.

(B) Very Short Answer Type Questions :

1. Define energy.
2. Define kinetic energy.
3. Define Potential energy.
4. Give the unit of mechanical energy.
5. Give an example of K.E.
6. Give one example of P.E.
7. List three non-renewable sources of energy.
8. List three renewable sources of energy.
9. Does a man standing at rest on a moving train possess kinetic energy ?
10. What happens to the energy which is used to move an object against friction ?
11. Does the mass of an object affect its kinetic energy ?
12. Give the unit of P.E.
13. Name some devices that utilise solar energy.

(C) Short Answer Type and Essay Type Questions :

1. As a rocket re-enters the atmosphere, its nose cone becomes very hot. Where did this heat energy come from ?
2. A ball hangs as a pendulum from a piece of string. If the pendulum is set swinging, it stops each time it comes to the end of its swing. Discuss the variation of K.E. and P.E. in this system by drawing a labelled diagram. Why does the pendulum eventually stop ?
3. What becomes of the original kinetic energy :

   (*i*) When a boy claps his hands together ? and (*ii*) When a hammer hits a nail ?
4. Various hydro-electric plants use water-driven turbines to generate electrical energy. Trace this energy back as far as you can toward its source.
5. Distinguish between K.E. and P.E. Give three examples of each.
6. State the law of conservation of energy and explain it with the help of an example from every day life.
7. What is transformation of energy ? Explain it with the help of two examples. Why is the transformation of energy useful ?
8. A ball rolling on the ground comes to rest. Where does its energy go ?

9. Mention the various sources of energy. Justify the statement that the sun is the ultimate source of all energies.

10. If energy is neither created nor destroyed, where does so much energy spent against friction in this life go ?

11. Give one example in each case, for the following transformation of energies:
    - (*i*) Chemical energy to electrical energy
    - (*ii*) Electrical energy to mechanical energy
    - (*iii*) Kinetic energy to potential energy
    - (*iv*) Electrical energy to light energy
    - (*v*) Electrical energy to sound energy
    - (*vi*) Mechanical energy to heat energy.

12. Following is a list of some of the different forms of energy. Give an example in each case :
    - (*i*) Potential energy
    - (*ii*) Kinetic energy
    - (*iii*) Heat energy
    - (*iv*) Chemical energy
    - (*v*) Electrical energy
    - (*vi*) Nuclear energy
    - (*vii*) Mechanical energy
    - (*viii*) Sound energy
    - (*ix*) Magnetic energy.

13. To lift a load a person must draw on his supply of food (*i.e.*,chemical) energy. In such a case what happens to the energy, does it get used up ?

14. Describe the *principle of energy transfers* involved in the following examples :
    - (*i*) A waterfall is used to turn a paddle wheel. The paddle wheel works a dynamo which in turn lights a lamp.
    - (*ii*) A battery drives an electric motor which works a pump to raise water from a well.
    - (*iii*) A piece of sodium metal is dropped into cold water. It reacts violently to produce a warm solution of sodium hydroxide.
    - (*iv*) A stretched spring contracts raising a load from the ground.

15. Give an example in each of the following energy transfers :
    - (*i*) Chemical energy to electrical energy to mechanical energy to potential energy.
    - (*ii*) Chemical energy to heat energy, light energy, and sound energy.

16. How can we minimise the energy losses in mechanical devices *viz.*, machines in factories and appliances in homes ?

17. Why should renewable sources of energy be encouraged ? How can we make judicious use of energy ?

18. A rubber ball is dropped from your hand. Describe the mechanical energy of the ball.
19. Describe the mode of energy transformation in a mechanical and an electric clock.
20. How can light energy be converted into mechanical energy ?
21. Describe the mechanical energy possessed by you as you go down a slide or ride a swing.
22. Give an example where the mechanical energy is the same as potential energy.

□□

CHAPTER 11

ORGANIZATION OF THE LIVING BODY

11.1 Introduction

All living bodies carry on life activities. Plants and animals are living bodies in nature. Human beings too have the same life activities as other animals.

You all remember the life activities of living organisms, such as, respiration, digestion, excretion, movement, growth, circulation, co-ordination and reproduction etc.

Where is the centre of these activities ?

Before 1600 A.D., man was ignorant about the structure of the centre of these activities in plants and animals. Around 1600 A.D., the compound microscope provided a new mode of observation of plants and animals to those interested in their study. **Leeuwenhoek (1632–1723) was the first to** observe and reported the presence of small organisms living in water.

11.2. The Cell

Robert Hook (1635–1703), an English scientist, developed the compound microscope. He examined a piece of cork under his microscope and observed that it was made up of 'box-like' structures in a honey comb (Fig.11.1). He called these structures 'cells'. Thus, Hook was the first to use term *cell.*

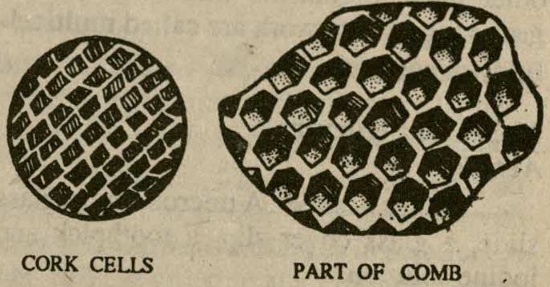


Fig.11.1. Cells seen by Robert Hook.

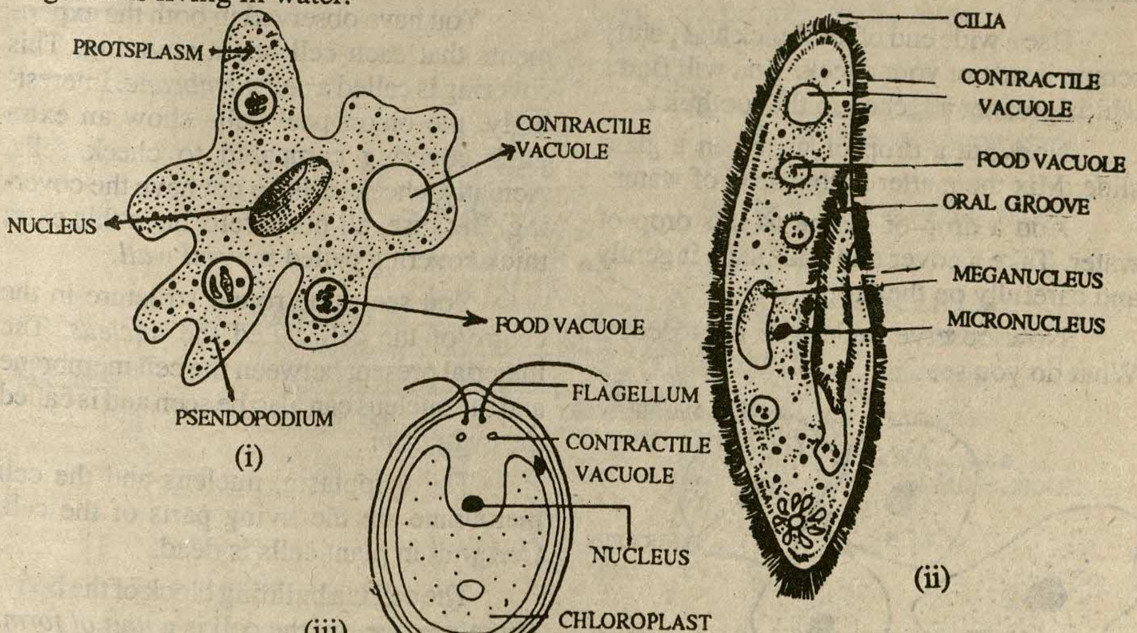


Fig. 11.2 Unicellular organisms — (i) Amoeba (ii) Paramaecium, and (iii) Chlamydomonas, showing single-celled structure.

Today we know that all living organisms are made up of cells. These cells are used in building up the body of living organism similar to bricks are used in the construction of house. A single cell has enormous abilities to carry all the vital life processes necessary for survival.

There are plants and animals, which have a single celled body. Such organisms are called *unicellular*. *Paramaecium, Amoeba* and *Chlamydomonas* etc., represent **unicellular organisms** (Fig.11.2). On the other hand, organisms where many cells group together to work are called **multicellular organisms.**

11.3. Cell Structure

Activity :

Things needed : A microscope, a glass slide, a glass cover slip, a toothpick and iodine solution.

Method :

Use a wide end of toothpick and gently scrape inside of your cheek. You will find a whitish matter attached to the toothpick.

Now put a drop of water on a glass slide. Mix the matter in this drop of water.

Add a drop of iodine to this drop of water. Take a cover slip and place it gently and carefully on the drop.

Now observe under the microscope. What do you see ?

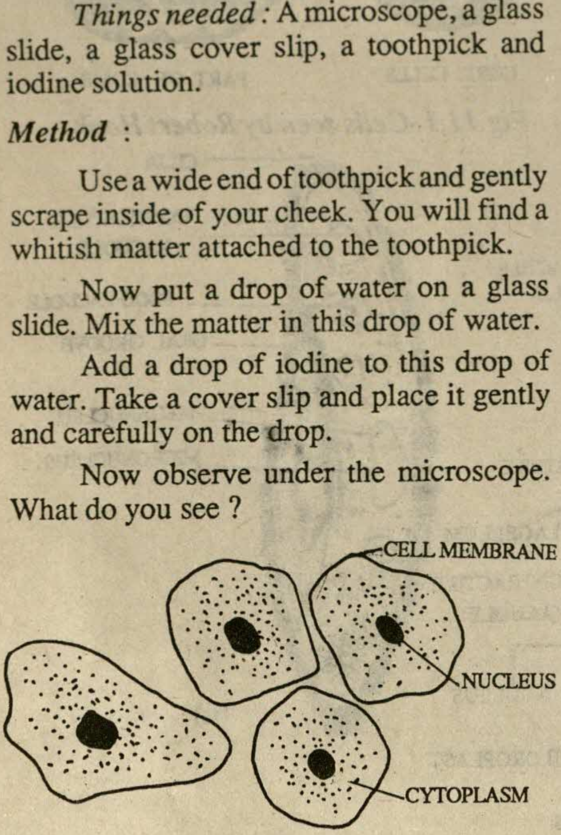


Fig.11.3. Cells from the inner lining of the mouth.

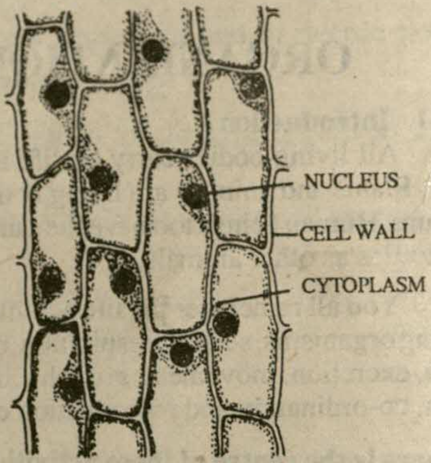


Fig 11.4 Cells from onion peel

Don't you see some cells as shown in Fig. 11.3 ?

Repeat the activity, instead of using the mouth material, use the inner peel of the chopped onion. You will, again, observe some cells, as shown in Fig. 11.4.

You have observed in both the experiments that each cell has a covering. This covering is called a *cell membrane*. Interestingly, the onion peel cells show an extra thick covering compared to cheek cells. Actually, cheek cells do not have the covering. Because, all plant cells have this extra thick covering called the *cell wall*.

You see same round structure in the centre of the cell called the *nucleus*. The material present between the cell membrane and the nucleus can also be seen and is called the *cytoplasm*.

The cytoplasm, nucleus and the cell membrane are the living parts of the cell. Cell wall in plant cells is dead.

The cell is a building block of the body. Therefore, we say the cell is a *unit of form*.

The cell can carry all the life activities, so we can say easily, it is a *unit of function*.

In other words, cell is a *unit of form* (structure) *and function*.

From the activity, it can be said that the cells of most plants and animals have nucleus, cytoplasm and cell membrane.

To observe the cell contents in detail, you need an electron microscope to magnify the cell.

Let us study a plant cell, and an animal cell, in detail, as magnified in Fig. 11.5 (*i, ii*).

Cell membrane

Each cell is surrounded by a living cell membrane or plasma membrane. The materials pass out or in selectivity through the cell membrane; therefore, it is called *a selecttively permeable or semipermeable membrane. A living cell membrane will always be semipermeable*. Plant cells have a cell wall surrounding the cell membrane. It is made up of cellulose and gives support and rigidity to the plant cells. Because of the presence of cell wall, plant cells have definite shape.

Cytoplasm

Cytoplasm is a semi-liquid substance. It occupies most part of the cell within the cell membrane. On examination under the microscope, cytoplasm appears to be colourless, partly transparent and somewhat watery. Many chemical reactions take place in the cytoplasm.

Embedded in the cytoplasm, there are many structures in addition to the nucleus, called *cell organelles*. Some such structures are described below :

(*a*) *Granules*. There are many small particles in the cytoplasm. These particles are believed to contain food materials, such as starch in plants and glycogen in animals.

(*b*) *Vacuoles*. There are certain clear spaces in the cytoplasm. They are filled with water and various substances in solution. A plant cell has one or many prominent vacuoles. An animal cell does not necessarily have such prominent vacuoles.

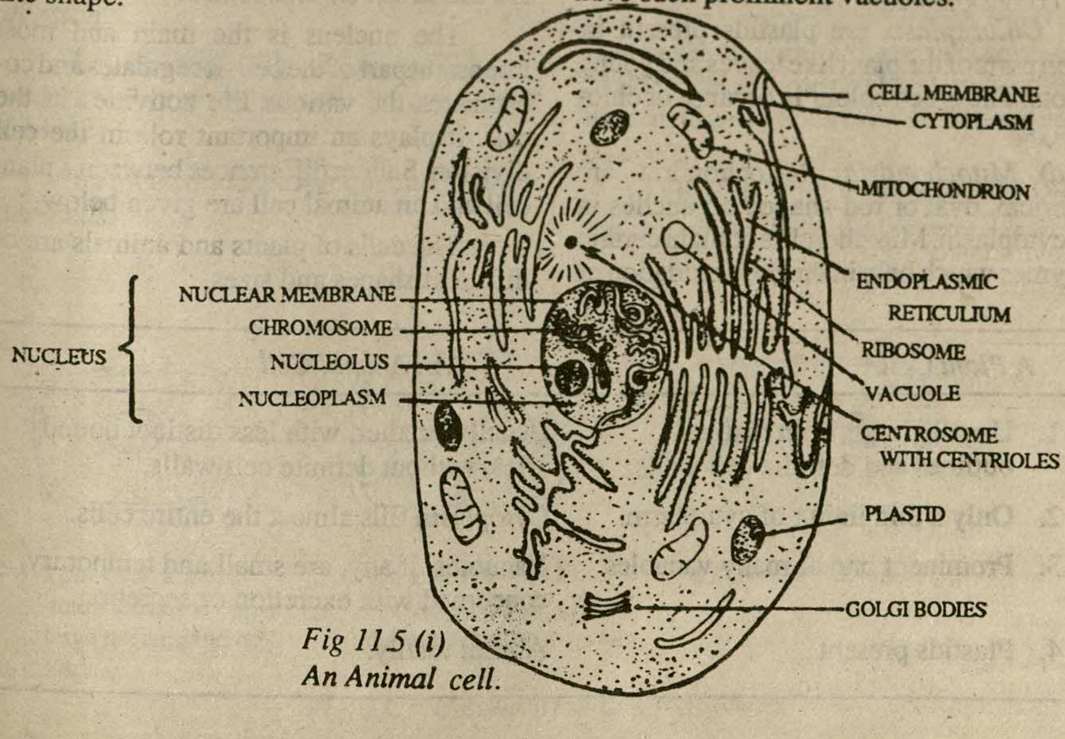
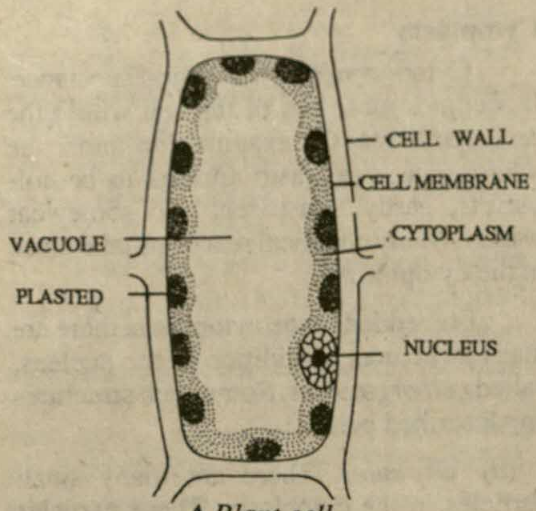


Fig 11.5 (i)
An Animal cell.



A Plant cell

Fig. 11.5 An Electron-micrograph of (ii) *Plant-cell.*

(*c*) *Plastids*. Plant cells contain some special structures called *plastids*. They are oval, spherical or disc-shaped bodies. Plastids are of different kinds depending upon the colour pigments, they possess.

Chloroplasts are plastids present in green parts of the plant like leaves and young shoots. The green colour is because of chlorophyll.

(*d*) *Mitochondria*. Mitochondria are spherical, oval or rod-shaped organelles in the cytoplasm. Mitochondria contain certain enzymes which help in the food oxidation of various nutrients that leads to release of energy. They are, therefore, popularly termed as the 'power houses' of a cell.

(*e*) *Endoplasmic Reticulum*. There is a complex network of very fine membranes traversing between the cell membrane and the nuclear membrane called the *endoplasmic reticulum*.

Nucleus

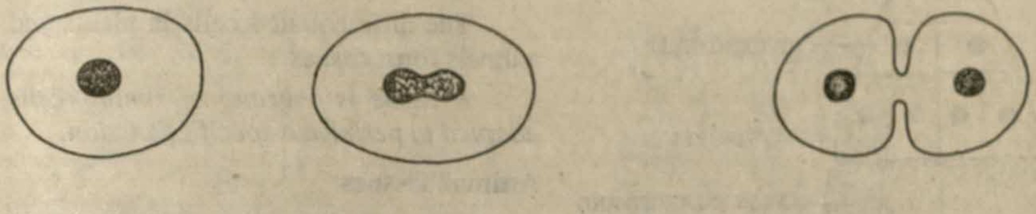
Nucleus is a small spherical mass in the cytoplasm. It has a delicate nuclear membrane within which is filled the relatively dense nucleoplasm. In the nucleoplasm, there are certain thread-like structures, called *chromosomes*.

The number of chromosomes is definite in each cell of an organism. For example, in human beings there are 46 chromosomes. In fruit fly (Drosophila), there are four. Chromosomes normally occur in pairs — there are specific pairs of chromosomes controlling the sex of an organism — these are called *sex chromosomes*.

The nucleus is the main and most important part of the cell. It regulates and coordinates the various life activities in the cell. It plays an important role in the cell division. Salient differences between a plant cell and an animal cell are given below :

The cells of plants and animals are of different shapes and sizes.

	A Plant Cell	*An Animal Cell*
1.	Usually large, with distinct outlines and definite cell walls.	Usually smaller, with less distinct boundaries, without definite cell walls.
2.	Only a thin lining of cytoplasm.	Cytoplasm fills almost the entire cells.
3.	Prominent one or many vacuoles.	Vacuoles, if any, are small and temporary, concerned with excretion or secretion.
4.	Plastids present	Absent totally.



(*a*) Animal cell about to divide

(*b*) The nucleus divides first

(*c*) The daughter nuclei separate and the cytoplasm pinches off between the nuclei to form two daughter cells.

Fig. 11.6 Cell division in an animal cell.

11.4. Cell division

In unicellular organisms, cells *multiply in number* by dividing their cell body.

How do multicellular organisms bring about increase in the number of cells? Here, too, the cell divides.

When plants and animals grow, their cells *increase in number* by dividing.

The dividing of the cell is called cell division.

Let us study Figs. 11.6 and 11.7 to understand how do animal and plant cells divide?

Each cell divides to produce *two daughter cells.*

There are *specific events* occurring in the nucleus, let the cell division takes place.

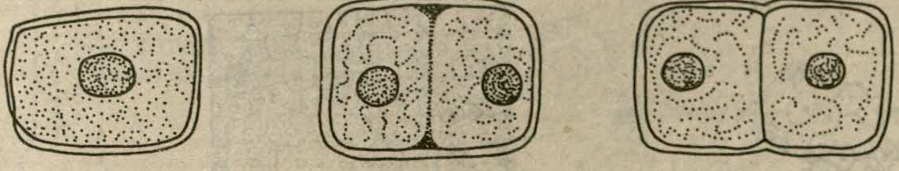
In animals and plants, there are *specific places*, where cell division occurs.

The cells present at the ends of bones, under the skin, are continuously dividing in animals.

In plants, the tip of roots and tip of stems are the regions, where cell divisions are very active.

There are cells, which undergo divisions even though they are not supposed to divide. The dividing cells form a group of unwanted cells. Such cells are called *cancerous cells.*

After the cell has divided, it grows. As the cell grows, it gets enlarged (Fig.11.8).



(*a*) A plant cell about to divide has a large nucleus and no vacuole

(*b*) The nucleus divides first. A new cell wall develops and separates the two cells.

(*c*) The daughter cells.

Fig. 11.7 Cell division in a plant cell.

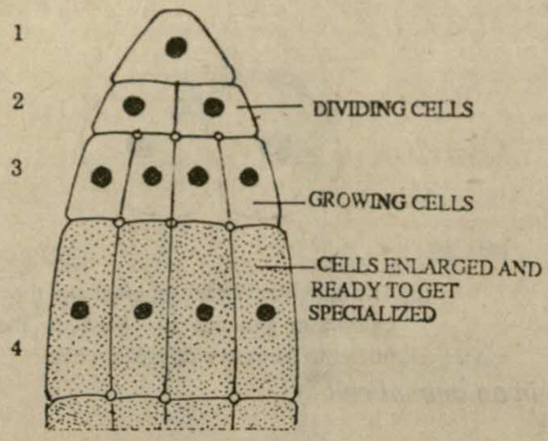


Fig. 11.8 Stages of cell enlargement.

The cells, which divide in organisms, are unspecialized. This indicates, they have no special function.

In unicellular organisms, a single cell performs all the *vital functions* ; whereas in multi-cellular organisms, cells get specialized to perform *special functions.*

11.5 Tissues

In multicellular organisms, again, cells are specialized to perform special functions. There are many types of cells. Particular type of cells take up a particular function. In other words, *different functions are performed by different types of cells.* Thus showing *division of labour* among cells. All these different types of cells have different shapes.

The process by which cells become different is called *cell differentiation.*

The differentiated cells in plants and animals form *tissues.*

A tissue is a group of similar cells adapted to perform a specific function.

Animal Tissues

The animal tissues are of four main types :

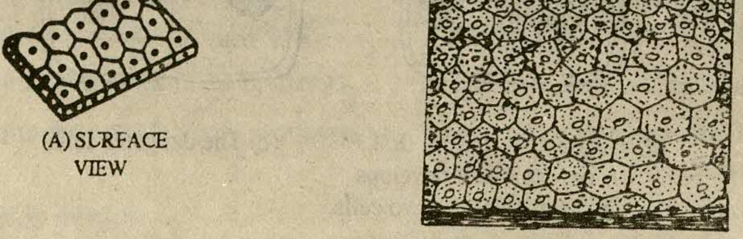
(1) Epithelial tissue
(2) Connective tissue
(3) Muscular tissue
(4) Nervous tissue.

1. Epithelial tissue :

Epithelial tissue is a thin, protective layer of cells (Fig.11.9). It covers the surface of the body and lines the various body cavities and internal organs ; including blood vessels. Epithelial cells may be cubical or columnar, in shape. The outermost layers of skin and the lining of surfaces of the mouth, nose, lungs, stomach, etc., are examples of this tissue.

You have observed the cells from inner lining of cheek, the kind of those cells are epithelial tissue.

Some epithelial tissues are much larger. They are specially modified to secrete chemical substances. Such cells form the *glandular epithelium* and are found in the lining of stomach and intestine.


(A) SURFACE VIEW

(B) SECTIONAL VIEW

Fig.11.9 Squamous Epithelium.

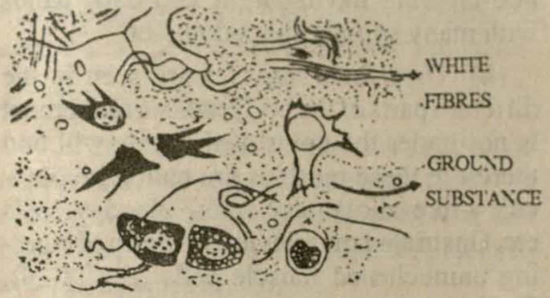


Fig. 11.10. Fibrous Connective Tissue.

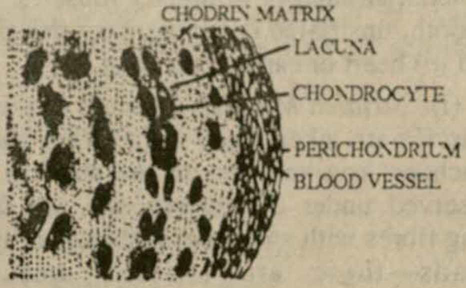


Fig.11.11 Cartilage

2. Connective tissue

Connective tissue is specialized for connecting various tissues and organs, or for supporting them to keep in their proper place. Some examples of connective tissue are *fibres, cartilage* and *bones*. Connective tissue consists of living ground substance or matrix (Fig.11.10).

Connective fibre tissues serve for packing and building most of the organs, *tendons*, which connect muscles to bones and *ligaments* which connect bones together are also connective tissue.

Cartilages are found in the nose, ears, rings of trachea and bronchial tubes, between vertebral, and at the ends of long bones and ribs (Fig.11.11).

Most vertebrates have skeleton made up of *bones* (Fig.11.12 *a* and *b*). Connective bone tissues help in forming the frame work of the body supporting and protecting the various body organs.

Blood is also a kind of fluid connective tissue. It is composed of both cellular and liquid parts. The liquid part is the *plasma* and the cellular part includes the *red blood corpuscles, white blood corpuscles* and *platelets*.

3. Muscular tissue

Muscular tissue forms the muscles of the body. The muscles contract and relax. Thus, they help the body in all its movements.

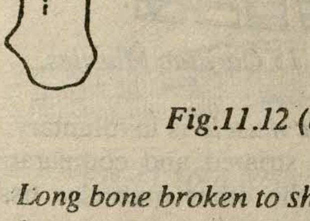


Fig.11.12 (a)

Long bone broken to show the hard bony tissue and the narrow cavity.

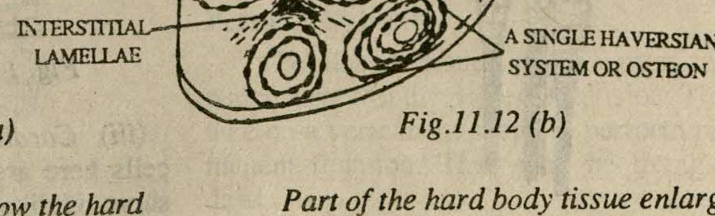


Fig.11.12 (b)

Part of the hard body tissue enlarged.

Three distinct kinds of muscles are (i) skeletal, striated or voluntary muscles, (*b*) smooth, unstriated or involuntary muscles, and (*c*) heart or cardiac muscles.

(*i*) *Striated Muscles.* If small fibres of muscles are taken from the leg of a cockroach or frog and put on the slide to be observed under the microscope, we find long fibres with striations as dark and light bands—these are striated muscles (Fig.11.13).

Striated muscles are present in all the parts of the body moving under the control of animal's will like limbs, neck, facial muscles etc. Therefore, these muscle fibres are called *voluntary fibres.* Each muscle fibre is long non-tapering having light and dark bands with many spindle shaped nuclei.

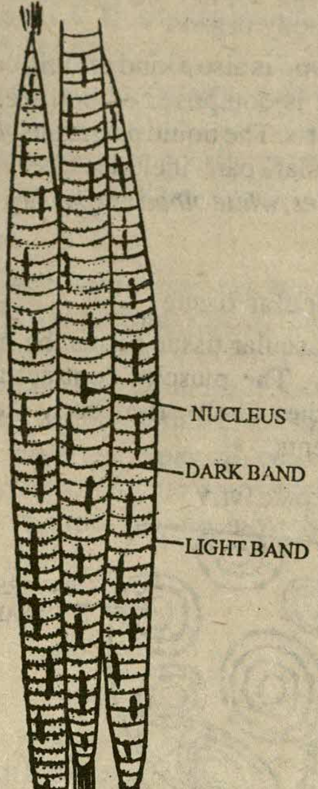


Fig.11.13 Striated Muscles.

(*ii*) *Unstriated muscles* are seen in the different parts of the body, whose movement is not under the control of man's will and therefore these muscles are called involuntary—like alimentary tract, blood vessels etc. Unstriated muscles are made up of tapering uninucleated muscle cells (Fig.11.14). These muscles are also called smooth muscles.

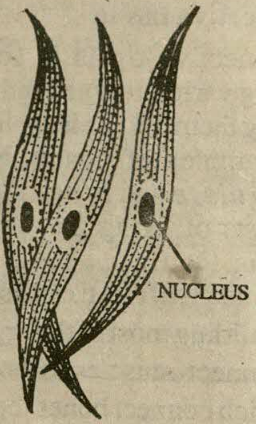


Fig.11.14 Unstriated Muscles

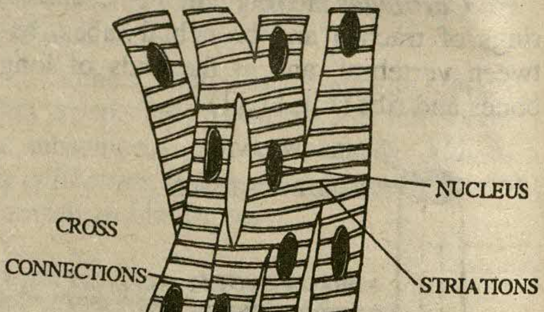


Fig. 11.15 Cardiac Muscles.

(*iii*) *Cardiac muscle* is involuntary. The cells here are striated and comparatively short. Unlike the other muscular tissues, cardiac muscle is branched. It is found only in the heart. Fig.11.15 shows that the muscles morphologically are like voluntary muscles and in function are like involuntary muscles.

4. **Nervous tissue.**

The basic units of nervous system are nerve cells or Neurons. They vary greatly in structure, but, in general, they have a cell body called a *cyton* with a central nucleus in cytoplasm (Fig.11.16).

In mammals and human beings, the cell bodies are confined to brain and spinal cord, while their filaments extend to the organs of the body. Neurons may be as long as $1\frac{1}{2}$ metres sometimes

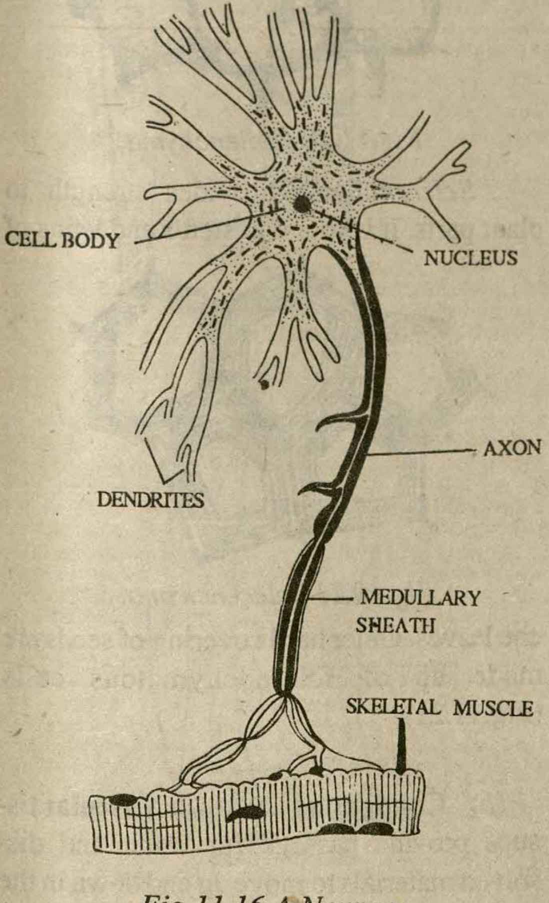


Fig.11.16 A Neuron.

The nerve cells help in conducting the nerve impulse all over in the body, thus, bringing about co-ordination in the whole animal body and making the body sensitive to various stimuli.

Plant Tissues

Plant tissues, basically, are of two types :

(1) Meristematic tissues

(2) Permanent tissues.

Meristematic tissue :

Meristematic tissue or *meristem* is the most fundamental. It is composed of small cells, which are filled with cytoplasm and have a large nucleus (Fig.11.17). These cells go on dividing and thus, responsible for bringing about growth of the plant. They also give rise to other types of plant tissue. This type of tissue is found at the tips of roots, stems and other plant structures, which grow.

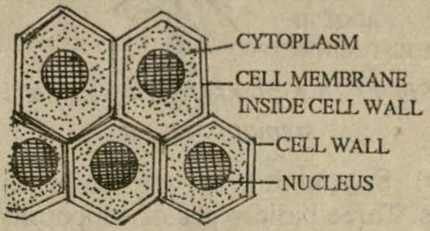


Fig.11.17 Meristematic tissue.

Observe a small plant (Fig.11.18).

The tips of the stem and root are two growing zones. These form the *meristematic zones.*

Permanent tissues :

Permanent tissues are made up of cells which have lost the power of division. They take on a permanent shape to perform permanent function. They may be living or dead.

Permanent tissues are of three types : *(a) supporting* tissues *(b) conducting* tissues or *vascular* tissue, *(c) dermal* tissues.

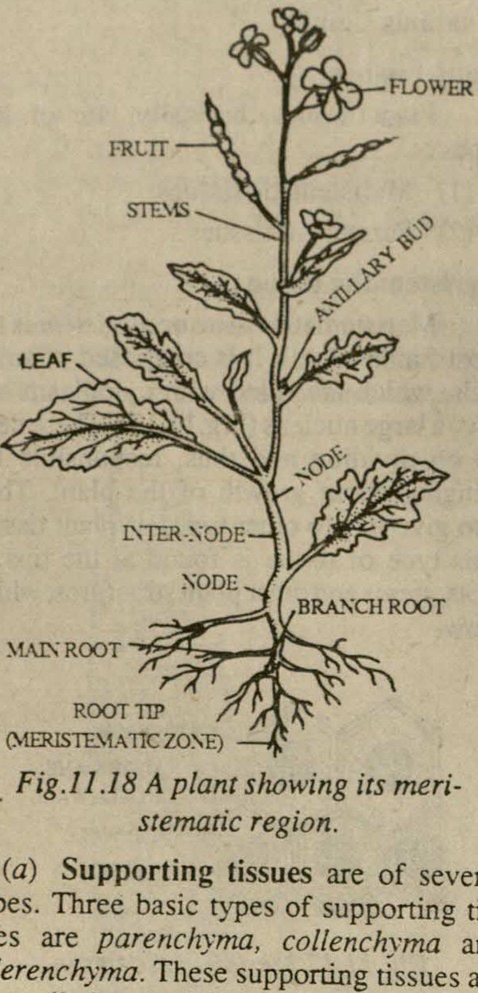


Fig.11.18 A plant showing its meristematic region.

(*a*) **Supporting tissues** are of several types. Three basic types of supporting tissues are *parenchyma, collenchyma* and *sclerenchyma*. These supporting tissues are also called ground tissues.

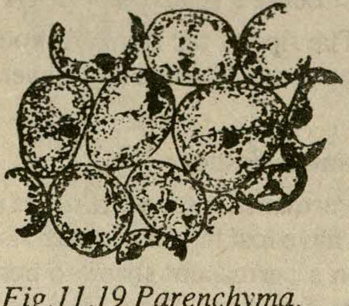


Fig.11.19 Parenchyma.

Parenchyma cells are found in soft parts of the plant. The cells are living (Fig.11.19). They store food material and also provide support temporarily. Some parenchymatous cells, particularly in the leaf, contain chloroplasts. The chloroplast helps in the manufacture of food, by photosynthesis.

Collenchyma is found in the leaf stalks and below the epidermis of stems. This tissue helps to support the plant parts (Fig.11.20).

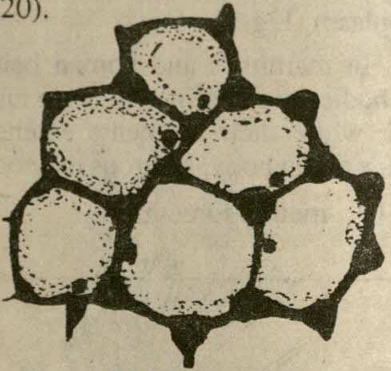


Fig.11.20 Collenchyma.

Sclerenchyma provides strength to plant parts. It is found in stems and veins of the leaves. Outer hard covering of seeds are made up of sclerenchymatous cells (Fig.11.21).

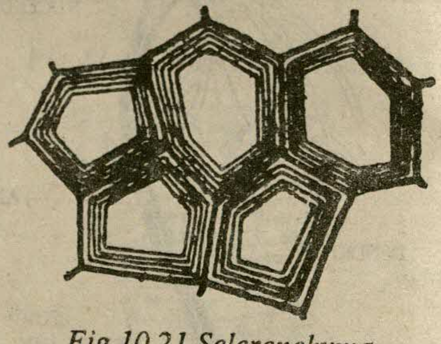


Fig.10.21 Sclerenchyma.

(*b*) **Conducting tissues or Vascular tissues** provide passage for water and dissolved materials to move up and down in the plant. Xylem and phloem are the two types of conducting tissues.

Xylem cells are thick-walled. They form a continuous passage for the upward movement of water and dissolved materials from the roots to other parts of the plant (Fig.11.22). *Xylem vessels* are formed by cells which are placed end to end forming structures like drain pipes. The walls of vessels are also variously thickened.

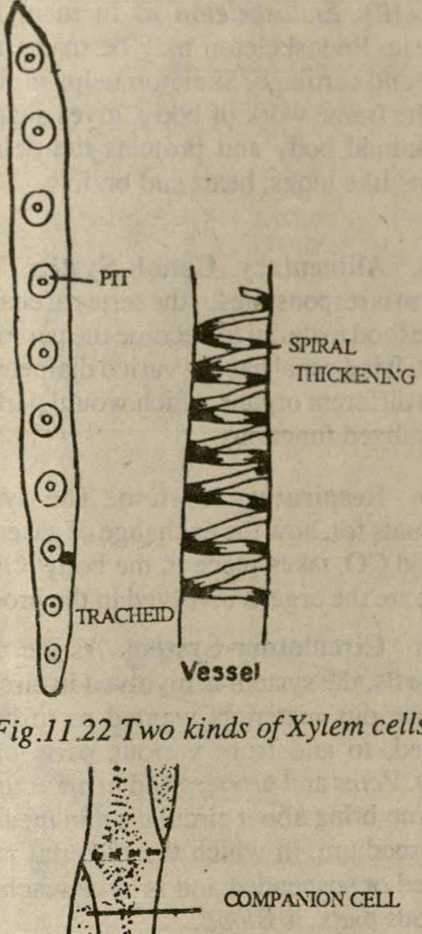


Fig.11.22 Two kinds of Xylem cells.

Phloem cells provide a passage for the downward movement of food, manufactured in the leaves to various parts of the plant (Fig.11.23).

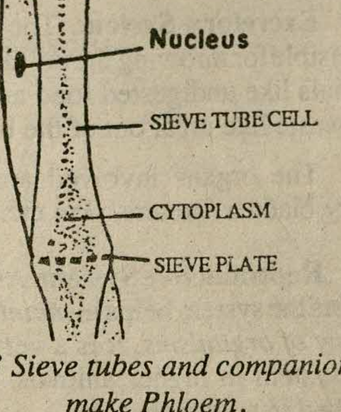


Fig.11.23 Sieve tubes and companion cells make Phloem.

Activity :

How does transport take place in plants ?

Take two balsam plants. Place one of them in a jar of plain water and other in a jar of coloured water. Keep for some time. The plant in the coloured water will show colour (Fig.11.24). How has the colour appeared on the stem and on the leaves ?

Observe the cut end of the stem. We will see that coloured patches are present only in certain areas of the stem. This is, where the conducting vessels are located. Xylem carries water and minerals absorbed by the root.

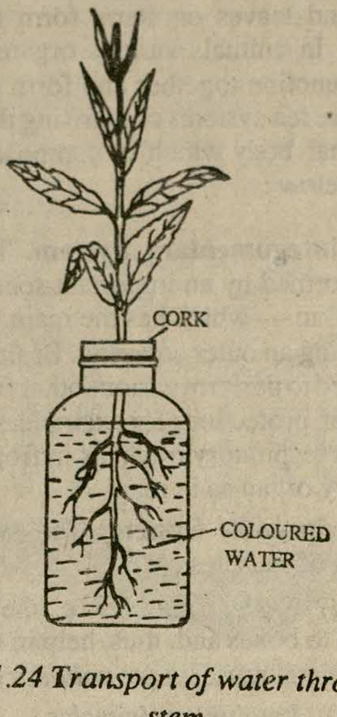


Fig. 11.24 Transport of water through the stem.

Xylem and phloem collectively form vascular bundles. The veins of leaves are examples of vascular bundles.

(*c*) **Dermal Tissues :** The tissues which form the covering of the different parts of the plant, are called dermal tissues. Roots, leaves and stem are protected by dermal tissue.

11.6 Organs — Systems and Organisms

An organ is made up of many tissues, which work in a co-operative and co-ordinated manner to perform a specific body function. The heart, the lung, the kidney and the liver are some examples of organs in animals. Roots, stems and leaves are examples of plant organs.

Many organs act together to perform a specific life process, such as digestion, excretion, etc. All these organs collectively constitute an *organ system*.

In plants, plant organs like flowers, fruits and leaves on stem, form the stem system. In animals various organs collectively function together and form systems. There are ten systems comprising the whole of animal body which is composed of as given below :

1. **Integumentary System.** The system is formed by an important sense organ — the Skin — which has the main function of forming an outer covering. Besides, *skin* is adapted to perform various other functions other than protection ; for example, skin also acts as a respiratory organ as in frog and an excretory organ as in man.

2. **Muscular System.** The system is made up of muscles :

(*i*) *Skeletal muscles i.e.,* the muscles attached to bones and, thus, help in locomotion. Skeletal muscles are *voluntary.*

(*ii*) *Involuntary muscles.*

3. **Skeletal System.** The system is formed by bone and cartilage — which in turn form the skeleton. Skeleton may be :

(*i*) *Exoskeleton* as in insects.

(*ii*) *Endoskeleton* as in man, frog, fish etc. Endoskeleton may be made up of bone and cartilage. Skeleton helps in forming the frame work of body, gives shape to the animal body and protects the delicate organs like lungs, heart and brain.

4. **Alimentary Canal System.** The system is responsible for the series of changes in the food material to become the part of the body. It is a canal having varied diameters to form different organs which would perform specialized functions.

5. **Respiratory System.** The system accounts for, how the exchange of gases like O_2 and CO_2 takes place in the body. Guess, what are the organs involved in the process.

6. **Circulatory System.** As the name suggests, the system is involved in circulating various materials wanted or to be removed, to and from various parts of the body. *Veins* and *arteries* and *heart* acting as a pump bring about circulation in the body. The medium, in which the material is dissolved or suspended and is to be reached to various parts, is *Blood.*

7. **Excretory System.** The system is responsible for throwing the unwanted waste materials like undigested food and nitrogenous waste like urea, out of the body.

The organs involved are kidneys, urinary bladder, ureters, skin etc.

8. **Reproductive System.** As the name suggests the system helps in *maintaining the progeny of organisms*. It is a very well defined system in higher animals. It will be described in a later chapter.

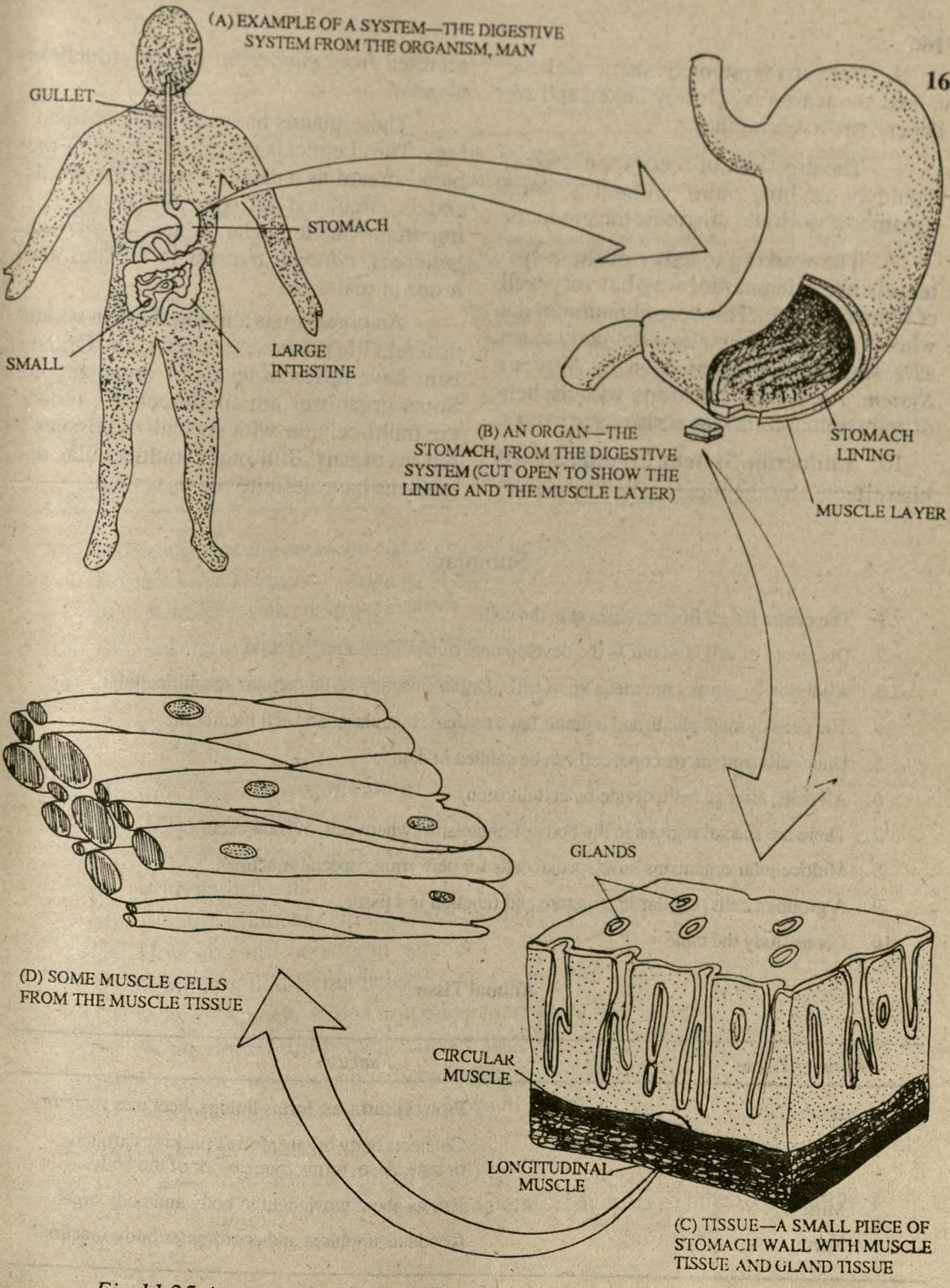

(A) EXAMPLE OF A SYSTEM—THE DIGESTIVE SYSTEM FROM THE ORGANISM, MAN
GULLET
STOMACH
SMALL
LARGE INTESTINE
(B) AN ORGAN—THE STOMACH, FROM THE DIGESTIVE SYSTEM (CUT OPEN TO SHOW THE LINING AND THE MUSCLE LAYER)
STOMACH LINING
MUSCLE LAYER
GLANDS
CIRCULAR MUSCLE
LONGITUDINAL MUSCLE
(C) TISSUE—A SMALL PIECE OF STOMACH WALL WITH MUSCLE TISSUE AND GLAND TISSUE
(D) SOME MUSCLE CELLS FROM THE MUSCLE TISSUE

Fig.11.25 An example of how cells, tissues, organs and systems are related.

9. **Nervous System.** Systems we have talked about are very closely linked and are dependent on each other.

The digestion of food, for example, would be of little value without a blood stream to absorb and distribute the products.

The working together of these systems is not in haphazard way but very well co-ordinated one. This co-ordination in the whole body system to allow the body to act as a single unit is carried on by *Nervous System.* The system functions with the help of brain, spinal cord, sense organs and nerves.

10. **Endocrine System.** Co-ordination is also effected by chemicals called ***hormones*** secreted from *endocrine glands* (ductless glands).

These glands have no ducts or openings. The chemicals they produce, enter the blood stream as it passes through the glands and is circulated all over the body. The important ductless glands are — *thyroid, pancreas, adrenal, ovaries* in females and *testes* in males etc.

An organism is a living thing in which different life processes are going on. Organisms have different levels of organization. Some organisms are single-celled ; others are multi-cellular with specialized tissues ; but no organs. Still other multicellular organisms have definite organ systems.

Summary

1. The centre for all life activities is in the cell.
2. Discovery of cell is as old as the development of compound microscope.
3. All living organisms are made up of cells. Organisms may be unicellular or multicellular.
4. The cells of most plants and animals have nucleus, cytoplasm and cell membrane.
5. Under electron microscope, cell can be studied in detail.
6. All cells, after growth, divide by cell division.
7. There are special regions in the body of organisms, where cell division occurs.
8. Multicellular organisms have special cells for performing special functions.
9. A group of cells, similar in structure and function is a tissue.
10. Let us study the table

Animal Tissues

Form of Tissue	*Function*
1. Epithelial	Protects surfaces, forms linings, becomes secretory.
2. Connective	Connects body organs, forms packings around organs. Also, forms frame work of the body.
3. Muscle	Brings about movement in body and body organs.
4. Nerve	Conducts impulses and coordinates body function.

Plant Tissues

Form of Tissue	Function
Meristematic Tissue	Actively involved in cell division, helps in active growth of plant body.
Permanent Tissue	
1. Parenchyma	Helps in storing food material. It contains chlorophyll, then helps in synthesis of food by the process of photosynthesis.
2. Collenchyma	Supporting tissue in the young green shoots of plants.
3. Sclerenchyma	Gives mechanical strength to the plants.
4. Xylem	Conducts water and minerals from roots to different parts of the plant.
5. Phloem	Conducts synthesized food from leaves to other parts of the plant.
6. Dermal Tissue	Outer covering for the parts of plant.

12. Different groups of tissues form organs in living organisms.
    Stomach, liver, kidneys etc.,are organs in animals.
    Root, stem, leaves etc.,are organs in plants.
13. Different organs form different organ systems
14. Different organ systems form an organism.

Questions

1. *Answer the following questions :*
   (*a*) What is a cell ?
   (*b*) Who discovered the microscope ?
   (*c*) Who named cell ?
   (*d*) What instrument helps to make a detailed study of a cell ?
   (*e*) How do cells increase in number ?
   (*f*) What is cell differentiation ?
   (*g*) Why is Amoeba called unicellular organism ?
   (*h*) When does a cell become cancerous ?
   (*i*) What are the growing regions in plants and animals.
   (*j*) What happens to cell when it stops dividing.
2. *Name the following :*
   (*i*) Tissue that protects animal body.
   (*ii*) Tissue that conducts water and mineral from roots to other parts of the plant.
   (*iii*) Supporting tissue of plants.

(*iv*) Tissue that helps in forming frame work of the human body.

(*v*) Tissue that is in the form of fluid in animal tissue.

(*vi*) Tissue where photosynthesis takes place in plants.

(*vii*) The main components of a cell.

(*viii*) The tissue that brings about the movement in animals.

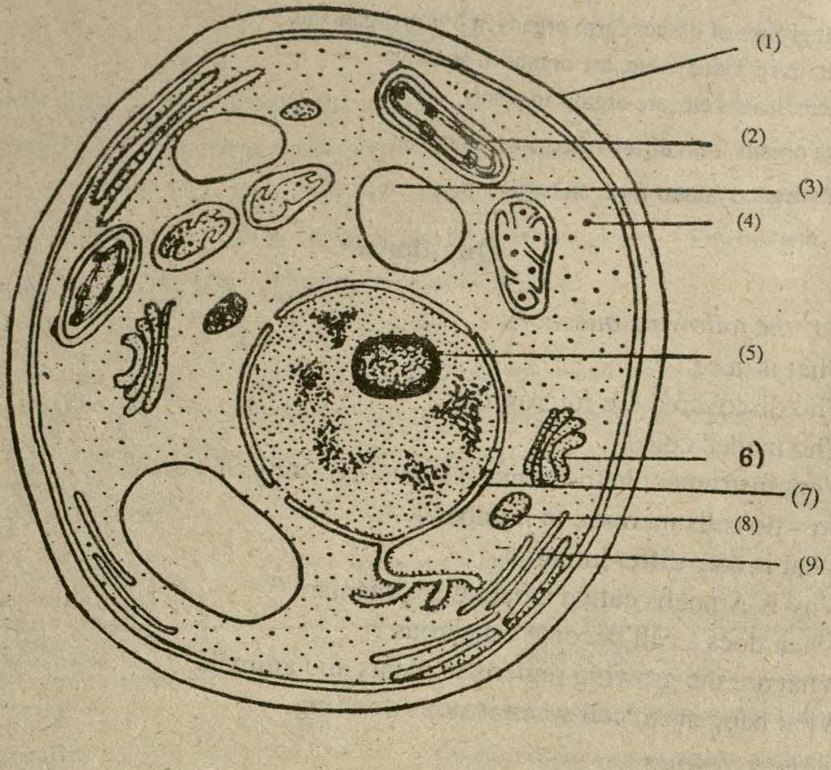
(*ix*) The region, where active cell division takes place, in plants.

(*x*) The tissue that brings coordination in the functioning of an animal body.

3. *Write the functions of the following :*

   1. Epithelial tissue
   2. Phloem tissue
   3. Striated muscle tissue
   4. Connective tissue
   5. Nucleus
   6. Cell membrane

4. Label the different parts of a cell (1–9) in the following diagram :



5. Name the different organ systems in a human body.

1. 2. 3. 4. 5.
6. 7. 8. 9.

6. Define the following terms :

1. Cell division 2. Tissue 3. Organ
4. Organ system. 5. Cell differentiation.

7. Differentiate between an animal cell and a plant cell.

Activities

Try to do the following activities with the help of your teacher in the class.

1. Collect some pond water. Observe a drop of pond water under the microscope. Note your observations.

2. Make a trip to a garden, or see some potted plants to recognize the growing zones.

□□

CHAPTER 12

WATER

12.1 General

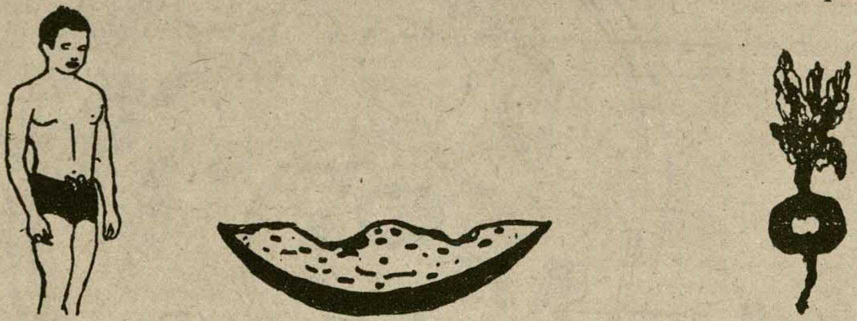
Have you ever been without water for a long period of time ? How did you feel ? If you have ever kept a pet, you are probably aware of the importance of water to life.

Water is an *inorganic compound.* It does not contain carbon and does not yield energy in the body. However, it is vital in a number of ways. About sixty to seventy percent of our body is comprised of water. Water is one of the main ingredients in protoplasm. About 92 per cent of liquid blood plasma is water.

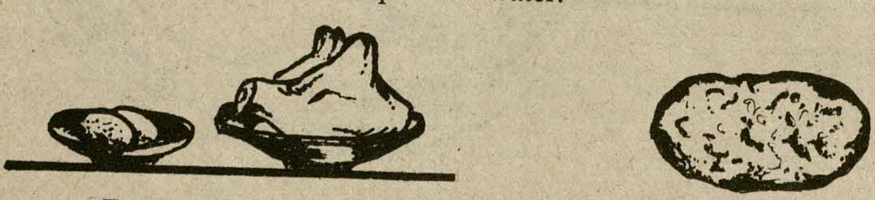
Water is also used in digestion to split complex food molecules chemically into simpler molecules. Water is the main solvent in the body. For instance, swallowed foods are dissolved in water, then only they are decomposed by the digestive tract. In the sweat glands of the skin and in the kidneys, uric acid is excreted and dissolved in water before it is passed from the body. The water that evaporates as perspiration from the surface of the body helps to regulate body temperature. The rate at which water evaporates from the body surface depends upon the temperature of the air and the relative humidity.

12.2 Water in Nature:

Water is one of the most abundant materials available to man. Man can obtain water from a variety of sources. The seas, rivers and lakes, which cover more than $\frac{3}{4}$ th of the earth's surface is formed of water only. During rain, some rain water is soaked by earth and percolates in the ground and, thus, making the soil wet. As and when rain occurs, the percolated water



Human body comprises 70 per cent water. Melons and lettuce contain up to 95 per cent water.



Eggs, meat and potato contain about 75 per cent water.

Fig.12.1 Percentage of water in human body and some food substances.

moves down the soil, until it meets a hard rock and the water is known as *ground water*. It is collected under the ground and begins to move towards an opening in the ground. When it finds an opening, it comes out and is called a *spring*. Springs feed wells, lakes and some rivers.

In the atmosphere, water is present in huge quantity in the form of vapours, mist or cloud.

Water from different sources has different properties.

All the food you eat contain water. Some are especially rich in this nutrient. Vegetables and fruits have a high water content. You obtain water by drinking it and also by drinking milk, juices and liquid food.

Some water is produced in the oxidation of food within the cells, as shown in the equation below :

$$\text{Glucose} + \text{Oxygen} \rightarrow \text{Carbon dioxide} + \text{Water}$$

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$$

The percentages of water, by mass present in some of the foodstuffs are given below :

Cucumber	95%	Turnip	88%
Meat	75%	Potato	75%
Egg	73%		

Some common substances apparently look dry such as dry splinters of wood, dry pulses, a few pieces of blotting paper, etc. If we heat these substances carefully without letting the contents char in the test tube, we will notice water droplets on the outer parts of the test tube.

12.3 Electrolysis of Water :

Take water in a bottle and add sodium hydroxide to make it better conductor. Pass an electric current. You will find the bubbles of gas forming at both the stainless steel rods and rising to the surface. To collect the gas stop the electric supply. Collect the gases in two test tubes by keeping them on the rods. Pass the electric current. You will see gas collected in one test tube is more than the other. The ratio of the collected gases be 2 : 1.

Test with a burning match stick. The gas in one of the test tube will burn with a pop sound and water will be formed, that gas is hydrogen.

In the other, match stick will catch fire and burn brightly. That gas is oxygen.

$$2H_2O \rightarrow 2H_2 + O_2$$

12.4 Solutions :

A solution is composed of two or more substances in which *the particles of the substances are uniformly distributed throughout*. No particle in a solution is larger than a molecule. Salt in water, iodine in alcohol, and oxygen in water are the examples of solution. Solution is a physical change, no chemical change takes place when a substance dissolves.

Sugar dissolves in water to form a sugar solution. The sugar molecules move to all parts of the water and mix with the water molecules. The same sweetness may be tasted in all parts of the solution.

The substance that is dissolved in a solution (sugar) is called the solute. The substance that dissolves the solute (water) is called the solvent.

solute + solvent → solution

A solute generally lowers the freezing point of a solvent in which it is dissolved. For this reason, anti-freeze (solute) may be added to water (solvent) in automobile radiators. However, the addition of solute to a solvent raises the boiling point. Table 1 gives some common examples of solutions.

TABLE I

Solute	Solvent	Common Example
1. Gas	Gas	Deep-sea divers gas, Helium in oxygen
2. Liquid	Gas	Open perfume bottle
3. Solid	Gas	Naphthalene in oil
4. Gas	Liquid	Welding–acetylene in acetone
5. Liquid	Liquid	Alcohol in water
6. Solid	Liquid	Sea water – salt in water
7. Gas	Solid	Gas stone lighter – Hydrogen in palladium
8. Liquid	Solid	Dental Mercury in cadmium
9. Solid	Solid	Ornaments – Silver in gold.

Suspensions

A mixture of solid and liquid material does not always produce a true solution. Frequently, when a solid and a liquid are mixed, a suspension is formed. A suspension is a state of a substance in which its particles are mixed, but are not dissolved. Sometimes, the particles in a suspension are microscopic. Sand and oil do not dissolve. Water on being shaken with sand or oil, becomes turbid due to the fine solid particles of sand or minute droplets of oil which remain suspended in water. Such a mixture is called a *suspension*.

12.5 Solubility

A solid dissolved in a liquid is the most common solution combination. The most common liquid solvent is water. Some substances dissolve readily in water, while others do not. The substance that does not dissolve in water is said to be *insoluble in water*.

The amount of a solid that may be dissolved in water depends largely upon the nature of the solid and the temperature of the water. For example, more table salt can be dissolved in water than copper sulphate ($CuSO_4$)

The solubility of a solute is the amount of the solute that can be dissolved in a given amount of a certain solvent.

When a solvent has dissolved the maximum amount of solute at a given temperature, it is said to be a *saturated solution*.

If additional solute is added to a saturated solution, the solute does not dissolve. It sinks to the bottom of the solution, where it remains.

The solution in which some more quantity of the solute can be dissolved at a fixed temperature is called an *unsaturated solution*.

A super saturated solution contains

more dissolved solute than the amount it would normally take to saturate it. A super saturated solution is often prepared by cooling a hot saturated solution very carefully to avoid separation of the excess solute.

Water is a very good solvent it dissolves many minerals, salts and gases also. Due to this property, dissolved oxygen of water is used up by aquatic animals for respiration.

12.6 Solubility of Gases

The solubility of gases in liquids is affected by the nature of the gas, temperature of the gas and the pressure of the gas. Some gases are more soluble than others.

A glass of the tap water often appears milky during hot summer season. This appearance is caused by tiny air bubbles in the water produced when some dissolved air is forced out from the water as it is heated. Air is a mixture of gases. As the water warms, air is released from solution and tiny bubbles are formed. The release of air bubbles from warm water shows that gases are less soluble in warm water than in cold water.

If a large amount of solute is present per unit volume, the solution is a *concentrated solution.* If only a small amount of solute is present per unit volume, the solution is a *dilute solution.*

12.7 Composition of Water

During the electrolysis of water, oxygen and hydrogen gases are liberated (Fig.12.2). The composition of water is :

Hydrogen	+	Oxygen	→	Water
2H	+	O_2	→	$2H_2O$
2 volumes		1 volume		2 volumes

Thus 2 volumes of hydrogen need 1 volume of oxygen to form 2 volumes of water. That is, the ratio of oxygen to hydrogen by volume in water 1 : 2.

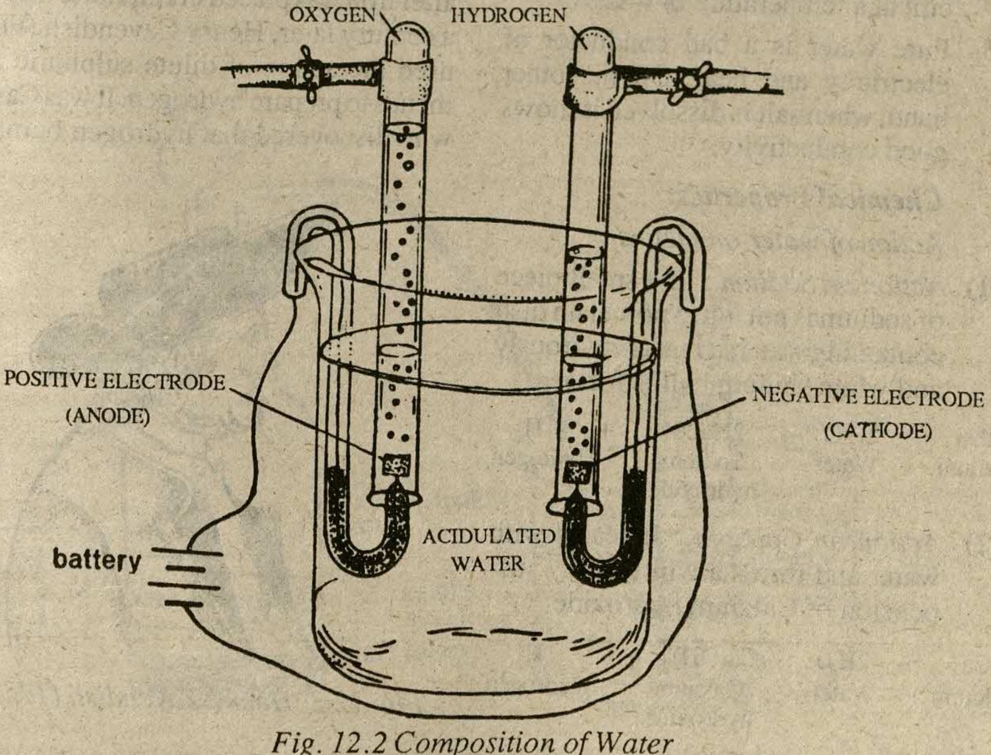


Fig. 12.2 Composition of Water

The mass of hydrogen atom is 1 and that of oxygen is 16. Thus the ratio of hydrogen to oxygen in water by mass is 2 : 16 *i.e.*, 1 : 8.

The ratio of hydrogen to oxygen remains constant in any sample of water.

12.8 Properties of Water

Physical Properties :

1. Water is a colourless and tasteless liquid.
2. Pure water freezes at 0°C and boils at 100°C, when the atmospheric pressure is 760 mm of mercury. Solid, when dissolved in water, increases the boiling point of water. At higher altitudes, the boiling point is decreased.
3. It does not have any effect on litmus, because it is neutral oxide.
4. It has the maximum density of 1 gm/cm^3 at a temperature of 4°C.
5. Pure water is a bad conductor of electricity and heat. On the other hand, when salt is dissolved it shows good conductivity.

Chemical Properties:

Action of water on metals

(1) *Action on Sodium* : If a small piece of sodium is put into a porcelain dish containing water, it reacts vigorously and white shining ball is formed.

$2Na$	$+$	$2H_2O$	$\rightarrow$	$2NaOH$	$+$	H_2
Sodium		Water		Sodium hydroxide		Hydrogen

(2) *Action on Calcium* : It reacts with water and forms a white milky suspension of Calcium hydroxide.

Ca	$+$	$2H_2O$	$\rightarrow$	$Ca(OH)_2$	$+$	H_2
Calcium		Water		Calcium hydroxide		Hydrogen

(3) *Action on Magnesium* : Heat small piece of magnesium ribbon and water in a test tube made up of hard glass. Magnesium burns with a bright dazzling light, leaving behind a white ash of Magnesium oxide.

Mg	$+$	HO	$\rightarrow$	MgO	$+$	H_2
Magnesium		Water		Magnesium oxide		Hydrogen

(4) *Action on Iron* : Iron reacts with steam at red hot temperature to form Iron oxide and hydrogen.

$3Fe$	$+$	$4H_2O$	$\rightarrow$	Fe_3O_4	$+$	$4H_2$
Iron		Steam		Tri-Iron tetra-oxide		Hydrogen

12.9 Hydrogen

It was seen in the property of water that hydrogen could be liberated from water (or steam) by the action of metals. Despite the abundance of water, its structure was not known. Just over 300 years ago the existence of hydrogen was suspected, when Robert Boyle observed bubbles of a gas coming out, after iron was placed in sulphuric acid. About a century later, Henry Cavendish (Fig. 12.3) used the action of dilute sulphuric acid on metals to prepare hydrogen. It was Cavendish who discovered that hydrogen burns and in

Fig. 12.3 Henry Cavendish (1731–1810)

year 1781 he proved that water is the only product obtained on the burning hydrogen in air.

Preparation of Hydrogen

The action of metals on water is either too violent so that, hydrogen cannot be collected, or, it is too slow if a reasonable large quantity of hydrogen is required. So in the laboratory, it is usual to use easier method, *i.e.,* action of dilute sulphuric acid or dilute hydrochloric acid on metals.

Laboratory Method

Take a few pieces of granulated zinc in a Woulfe's bottle. Add dilute hydrochloric acid through the thistle funnel. A vigorous reaction takes place with the evolution of a gas.

Zinc + dilute hydrochloric acid →
Zinc chloride + Hydrogen

$Zn + 2HCl \rightarrow ZnCl_2 + H_2$

Now collect the gas by the downward displacement of water as shown in the Fig. 12.4.

12.10 Physical Properties

Collect the gas in several gas jars and study these properties – (*i*) colour (*ii*) smell or odour (*iii*) solubility.

Hydrogen is a colourless gas. It is very slightly soluble in water and that is why we collect it by the downward displacement of water.

(*iv*) It is less dense than air.

To show that hydrogen is less dense than air.

Place a dry test tube containing air over a tube of hydrogen as shown in the Fig. 12.5. After a few seconds, test the upper tube with a burning match stick. The 'pop' sound shows that hydrogen has flowed upwards.

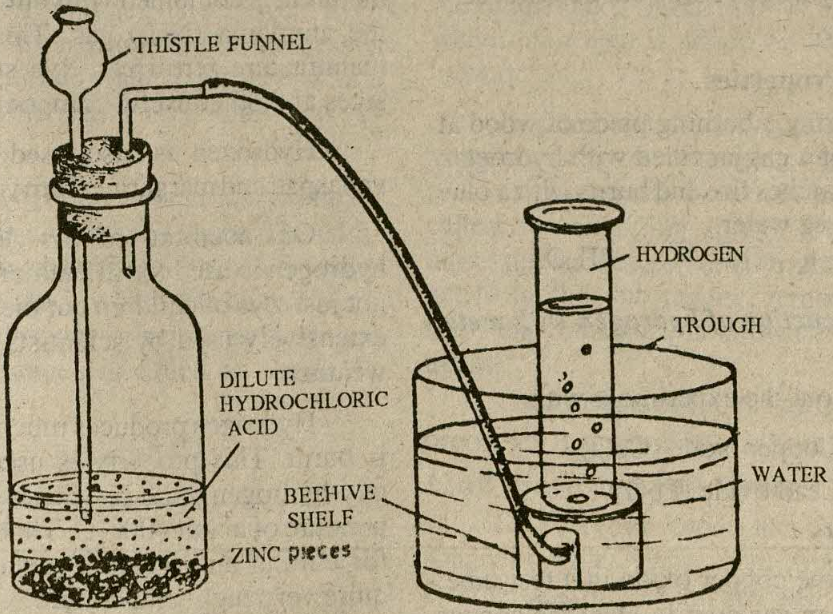


Fig. 12.4 Preparation of Hydrogen by the action of zinc on dilute hydrochloric acid.

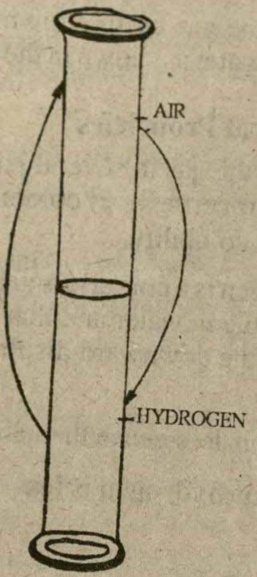


Fig. 12.5 Hydrogen escapes upwards showing that it is lighter than air.

It is the lightest gas known.

(*v*) It can be liquefied by the application of low temperature and high pressure.

(*vi*) Hydrogen burns but does not support burning.

Chemical Properties

(1) Bring a burning piece of wood at the mouth of a gas jar filled with hydrogen. Hydrogen catches fire and burns with a blue flame forming water.

$$2H_2 + O_2 \rightarrow 2H_2O$$

(2) ***Reaction of hydrogen with metal oxides.***

Carry out the experiment with

(*i*) Copper oxide (CuO)

(*ii*) Lead oxide (PbO).

Experiment :

Put some copper oxide in a test tube. Pass hydrogen gas over it. Heat the copper oxide gently and observe any changes which take place.

When hydrogen gas is passed over the heated black copper oxide, it removes oxygen from the copper oxide and a reddish substance is formed. The reddish substance is metallic copper.

Copper oxide + Hydrogen → Copper + Water

$CuO + H_2 \rightarrow Cu + H_2O$

Similarly, when hydrogen is passed over heated lead oxide, water and lead are formed.

Hydrogen + Lead oxide → Water + Lead

$H_2O + PbO \rightarrow H_2O + Pb$

Uses of Hydrogen

All acids contain hydrogen. It is also present in many minerals, vegetables, animal organisms, coal, oil, wood, petroleum and natural inflammable gases. It is present in all foods, such as starch, fat, seed oils, sugar and proteins.

Most of the hydrogen, which is manufactured, is combined with nitrogen to form the ammonia (NH_3) gas. This is used to manufacture fertilizers, dye stuffs, explosives and other useful compounds.

Hydrogen is also used for making vanaspati and margarine from vegetable oils.

On account of its low density hydrogen is used to fill balloons. These are not just toys of children but the balloons are extensively used by scientists to study the weather.

Hydrogen produces much heat while it is burnt. This property is used in making oxy-hydrogen torch which can attain a temperature of about 4000 °C. This torch is used for cutting and welding metals which require very high temperature.

It is often used as a reducing agent for the extraction of metals from their oxides.

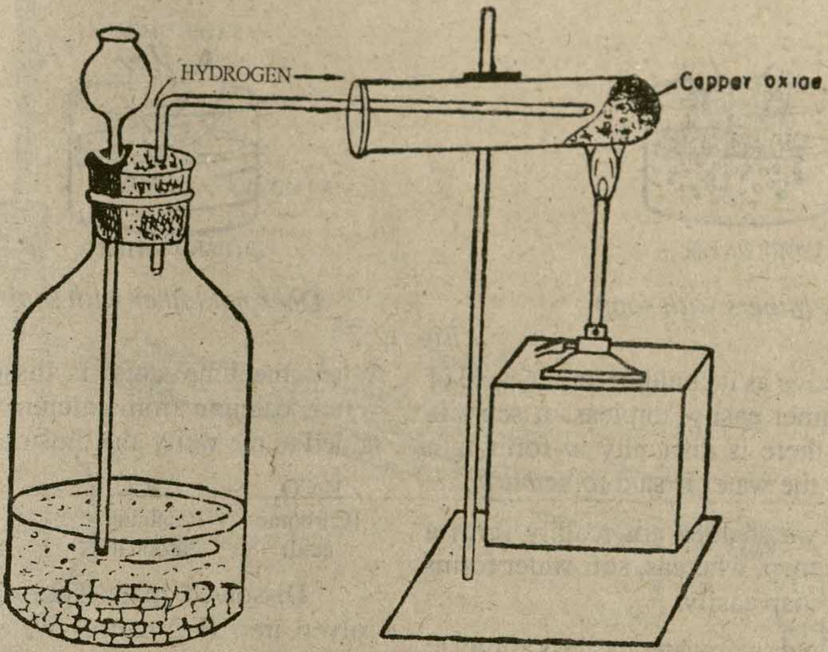
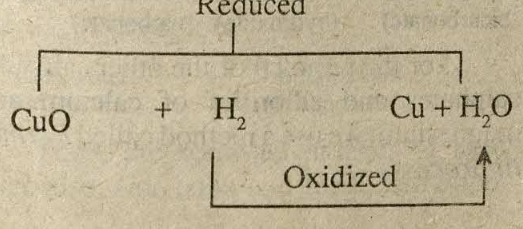


Fig. 12.6 Hydrogen reduces heated copper oxide to copper metal.

12.11 Oxidation and Reduction

Consider the reaction of copper oxide with hydrogen. Oxygen is removed from copper oxide by hydrogen. This process is known as *reduction* and hydrogen which brings about the reduction is known as *reducing agent.*

Oxygen of copper oxide has combined with hydrogen and formed water. The addition of oxygen to hydrogen is called *oxidation.* The substance which transfers oxygen to another substance or removes hydrogen from the substance is called an *oxidizing agent.*



Thus 'oxidation' is a process in which oxygen is added or hydrogen is removed. On the other hand, 'reduction' is a process in which hydrogen is added or oxygen is removed.

In other words, the substance which transfers oxygen to another substance or removes hydrogen from that substance is called an 'oxidizing agent'. On the other hand, the substance which transfers hydrogen to another substance or removes oxygen from that substance is known as 'reducing agent'.

Oxidation is one of the most important processes that occur in our bodies.

12.12 Hard and Soft Water

Of everyday importance is the use of soap with water for personal cleanliness and for the washing of dishes and clothes. In some cases of hand pump water the soap is

Easily lathers with soap

Does not lather with soap

Fig. 12.7

not as effective as it could be and instead of getting a lather easily, unpleasant scum is formed. If there is difficulty in forming a lather, then the water is said to be *hard*.

Hard water does not readily form a lather with soap, whereas, soft water forms lather with soap easily.

Well and river water has less ability to produce lather while tap water forming more lather is called *soft water*.

Hard water is responsible for the formation of the ring you may have observed around the inside of a washbowl or bath tub. It also leaves a scaly, mineral deposit in water boilers and in kitchen utensils used to heat hard water.

Hard water contains minerals namely, Calcium (Ca), Magnesium (Mg) or Iron (Fe) in a dissolved state. Soft water is nearly free from such dissolved minerals. Soft rain water absorbs CO_2 from the air as it falls from clouds to earth. CO_2 dissolved in the rain water forms a weak acid solution. The addition of CO_2 to water produces Carbonic acid (H_2CO_3).

$$CO_2 + H_2O \rightarrow H_2CO_3 \text{ (Carbonic acid)}$$

When carbonic acid, a weak acid, is placed in contact with limestone rock, it dissolves the lime stone. Lime stone rock is composed of calcium carbonate ($CaCO_3$). When the lime stone is dissolved in the water, calcium from calcium carbonate is added to the water and thus make it hard.

$$\underset{\text{(Carbonic acid)}}{H_2CO_3} + \underset{\text{(Calcium carbonate)}}{CaCO_3} \rightarrow \underset{\text{(Calcium bicarbonate)}}{Ca(HCO_3)_2}$$

Dissolved magnesium (Mg) or dissolved iron (Fe) causes water to become hard.

Hardness can be removed by *distillation*. When water changes into steam or vapours and, again, it is condensed back to water, this is *distillation*. This distilled water does not contain any mineral salts. That is why, it is not good for drinking purpose. Still, it is widely used in car batteries, hospitals, etc.

Temporary hardness can be removed by using *Clark's process*. This involves the addition of a carefully calculated amount of calcium hydroxide to the hard water so that the calcium is removed as the insoluble carbonate.

$$\underset{\text{(Calcium bicarbonate)}}{Ca(HCO_3)_2} + \underset{\text{(Calcium (hydroxide)}}{Ca(OH)_2} \rightarrow \underset{\text{(Calcium carbonate)}}{2CaCO_3} + \underset{\text{(Water)}}{2H_2O}$$

For the removal of the other salts like sulphates and chlorides of calcium and magnesium, we use a method called *Permutit process*.

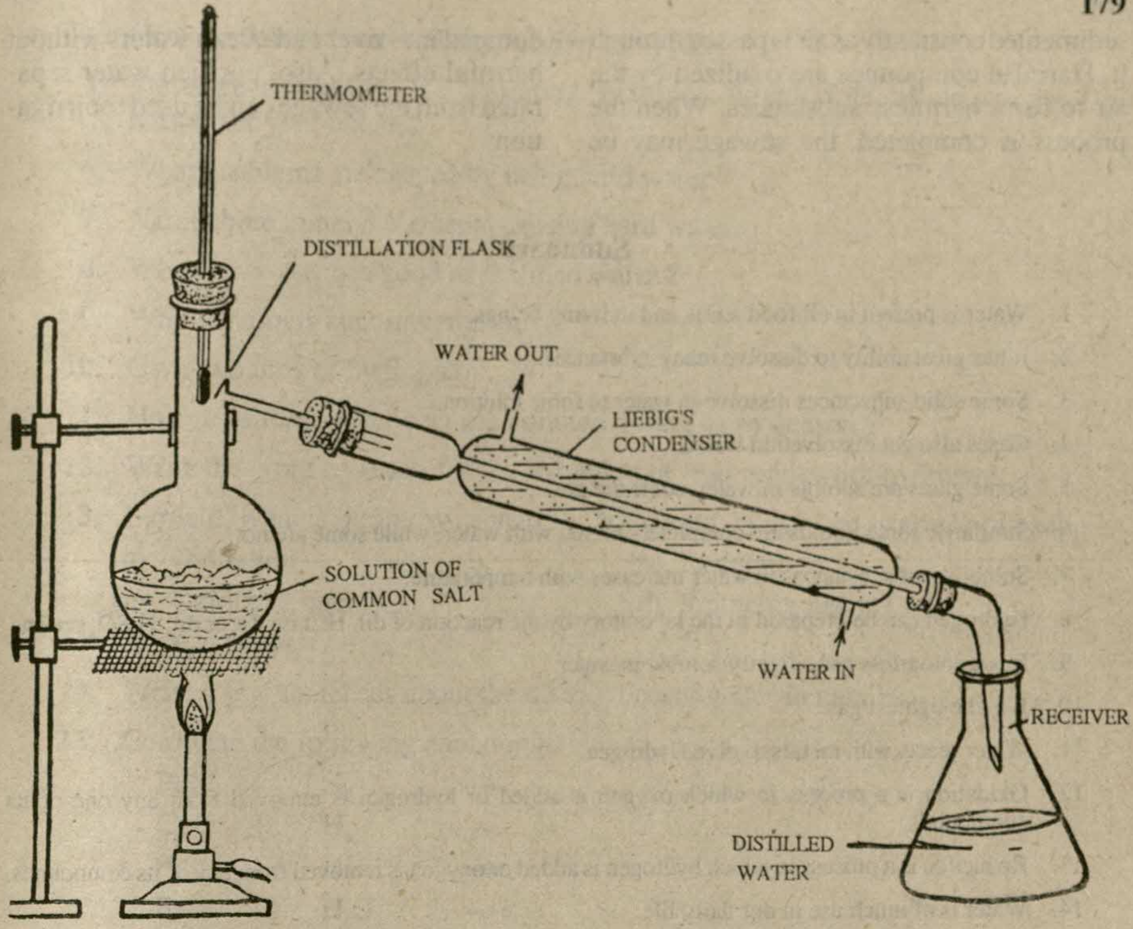


Fig. 12.8 Distillation in the laboratory

Washing soda (Na_2CO_3) is one of the compounds used to remove dissolved calcium from hard water.

$CaCl_2$ +	Na_2CO_3 →	$CaCO_3\downarrow$ +	$2NaCl$
(Calcium chloride)	(Sodium carbonate)	(Calcium carbonate)	(Sodium chloride)

Sodium Zeolite is very effective in softening hard water. When hard water passes over the zeolite, it (zeolite) absorbs the dissolved calcium in the hard water and replaces it with sodium.

Hard water + Sodium zeolite →
Calcium zeolite + soft water.

There are some advantages of hard water also. For bone and teeth formation, calcium is an essential item of diet and so the best drinking water contains calcium.

12.13 Water Pollution

Water pollution is a problem in many streams and rivers. In some localities, factory owners dump industrial wastes, directly into nearby waters. Some big cities release untreated sewage into the rivers and oceans. These wastes kill the fish in rivers and streams and make the water unfit for bathing and other recreational activities.

Sewage treatment plants aid water conservation. In a sewage treatment plant, the sewage is stored in large tanks where it is sedimented constantly as air is passed through it. Harmful compounds are oxidized by the air to form harmless substances. When the process is completed, the sewage may be dumped into river and ocean waters without harmful effects. Also, purified water separated from the sewage can be used for irrigation.

Summary

1. Water is present in all food stuffs and in living beings.
2. It has great ability to dissolve many substances.
3. Some solid substances dissolve in water to form solution.
4. Gases also get dissolved in water.
5. Some gases are soluble in water, some are not.
6. Similarly, some liquids are completely mixed with water, while some are not.
7. Solubility of substances in water increases with temperature.
8. Hydrogen can be prepared in the laboratory by the reaction of dil. HCl on Zn or dil. H_2SO_4 on Zn.
9. It is a colourless gas, slightly soluble in water.
10. It is the lightest gas.
11. Water reacts with metals to give Hydrogen.
12. Oxidation is a process in which oxygen is added or hydrogen is removed from any one of its compounds.
13. Reduction is a process in which hydrogen is added or oxygen is removed from any of its compounds.
14. Water is of much use in our daily life.
15. Some water is hard and some is soft.
16. Hardness is due to the presence of $CaCl_2$, $MgCl_2$, $CaSO_4$, $MgSO_4$, $Ca(HCO_3)_2$ $Mg(HCO_3)_2$ etc.
17. It can be removed by boiling water, by adding lime or by the permutit method.
18. Hard water has got some advantages also. For bone and teeth formation, calcium is an essential item of diet.
19. Some big cities release untreated sewage into the rivers and oceans, which causes water pollution.
20. Electrolysis is the method of using electricity to break down molecules.

Questions

1. Why do we feel uncomfortable on a hot humid day ?
2. State the uses of water in your body.
3. Define solution, solute and solvent, Give one example of each of the above terms.

4. How do fish and water plants survive in water.
5. Metals react with dil. HCl, liberating Hydrogen. Which metal would you use ? Give reason for your choice.
6. What problems are caused by using hard water ?
7. Name three mineral elements causing hard water.
8. Why rain water is a good as distilled water ?
9. Why sodium is kept in kerosene oil ?
10. Give two uses of hydrogen.
11. How does river water become polluted during rainy season ?
12. Write the word equation for the reduction of lead oxide with hydrogen.
13. Explain, what is meant by each of the following ? Give one example of each :
    (*a*) Oxidation (*b*) Reduction
    (*c*) Oxidizing agent (*d*) Reducing agent
    (*e*) Electrolysis.
14. Write a few sentences about the distribution of water in nature.
15. Complete the following equations :

$PbO + H_2 \rightarrow$

$CuO + H_2 \rightarrow$

$Zn + HCl \rightarrow$

$Fe + H_2O \rightarrow$

$Al + MnO_2 \rightarrow$

Activities

(1) Solubility varies with the temperature and the amount of solvent.

(2) Showing the effect of saline water on seedling.

(3) Testing of hardness with soap.

(4) Listing sources of water pollution in the locality.

CHAPTER 13

AIR

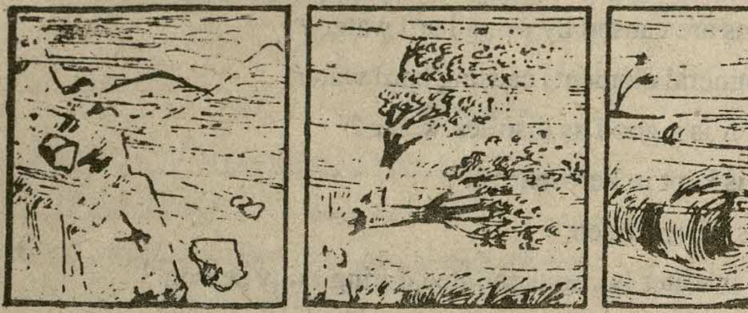


Fig. 13.1 Moving Air

13.1 Air

Air is all around us. Although air is invisible, there are many ways in which it can be detected. If you hold your fingers in front of your nose, you can sense air movement as you exhale during respiration. Moving air can make a tree's branches sway back and forth. And the force of air can push a balloon filled with helium high up into the sky. We live at the bottom of an ocean of air which surrounds the earth.

13.2 Composition of the Atmosphere

The atmosphere is the air which surrounds the earth and extends about 960 km above its surface.

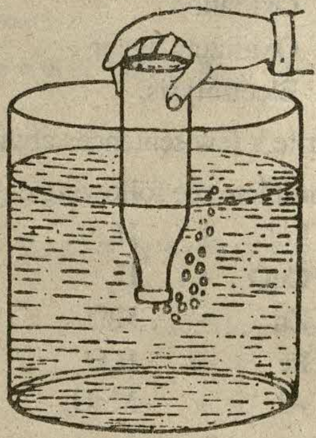


Fig. 13.2 Air bubbles rush out of an empty bottle when dipped in water.

Invert a glass bottle and press it into the water inside a big jar (Fig.13.2). Does the water fill the bottle?

Air occupies space and has weight. Air is a mixture of gases, fine dust particles and water vapours. Its gases are mostly nitrogen and oxygen. About 78 percent of air is nitrogen (N_2) and about 21 percent is oxygen (O_2), making a total of 99 percent (Table 1). The remaining 1 per cent of the air is argon (Ar), carbon dioxide (CO_2) and minute amounts of other gases (Fig.13.3).

TABLE 1

Gas	*Per cent by Volume*	*Minute Amount*	
Nitrogen	78.09	Neon	Xenon
Oxygen	20.95	Helium	Radon
Argon	0.93	Krypton	Water Vapour
Carbon dioxide	0.03	Hydrogen	

The outer limit of the air surrounding the earth is indefinite. However, air is very dense near the surface of the earth and becomes less dense with increased altitude. This occurs because the force of gravity, the major factor that prevents the atmosphere from drifting into space, is stronger near the earth's surface.

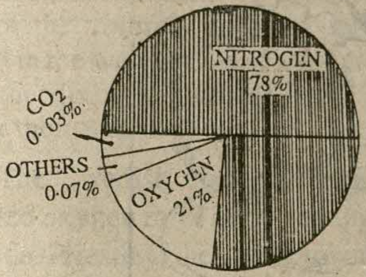


Fig. 13.3 Composition of Air.

The portion of the atmosphere about 12 km above the earth is called the *troposphere*. Almost all weather activity occurs in this layer. As you leave the earth's surface and go higher in the troposphere, the temperature continually decreases. The decrease is fairly constant.

The upper boundary of the troposphere is called the *tropopause*. Beyond the tropopause is the *stratosphere*. The upper limit of the stratosphere is called the *stratopause*. Beyond it, is an extremely thin layer of atmosphere known as the *ionosphere*. It is named ionosphere because it contains a great concentration of electrically charged atoms called *ions*. The composition of the ionosphere is also unique because it is rich in a form of oxygen called *ozone* (O_3).

The ionosphere is a great aid to radio communication. Radar is one kind of radio wave which passes through the ionosphere.

Weather is the condition of the atmosphere at a particular time.

Climate is the average weather over a long period of time.

The scientific study of weather and climate is called *meteorology*.

There are human beings, plants and animals in a locality. They all share air, water and soil. So environment in which we live is also the environment for others. This may be disturbed in various ways. The disturbance often cause changes, and such changes bring about further disturbances. The addition of any substance in excess of that normally present in the environment also disturbs it. These disturbances are called *pollution*.

13.3 Air Pollution

The contamination of the air by such substances as toxic dust, vapours and other fumes is called *air pollution*.

The air of big cities is polluted (Fig.13.4). It contains tons of material released from smoke-stocks, industries and motor vehicles. Polluted air is unpleasant to breathe and it contains poisonous substances which are harmful to health. Many physicians believe that polluted air contributes to conditions, such as, respiratory infections, lung cancer, allergies and several other diseases.

Unburned hydrocarbons, oxides of nitrogen, ozone and sulphur dioxide are some of the chief contaminants present in polluted air. Many of the contaminants result from the burning of coal and fuel oil. Many industries release poisonous gases such as sulphur dioxide and carbon monoxide with the air. Motor vehicles also release unburned hydrocarbons, carbon monoxide and oxides of

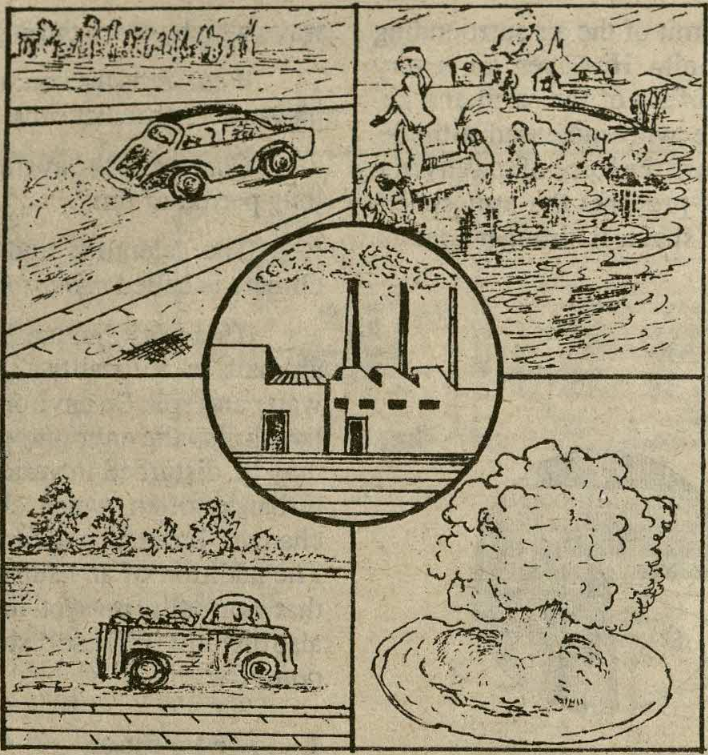


Fig. 13.4. Pollution in modern age.

nitrogen. Oxides of nitrogen such as nitric oxide and nitrogen dioxide are essential to the production of photo-chemical smog that irritates the eyes, nose, throat and lungs.

When waste products from the combination of coal and oil are released into the atmosphere, they form a suspension of finely divided solid particles. These particles are suspended in the gases of the atmosphere. The particles may cause the air to have a gray, hazy appearance and frequently referred to as smoke.

Hydrocarbons and oxides of nitrogen and gases are released into the atmosphere from the exhaust of gasolene and diesel engines. When these exhaust gases are acted upon by sunlight, they are chemically changed. One of the products of this chemical change is ozone. It is an allotrope of oxygen. It causes irritation to the lungs of the nose and throat. Ozone and other gases resulting from a photochemical change are called *smog*.

13.4 Prevention of Air Pollution

Air pollution can be prevented by different methods.

One method of eliminating air pollution is the *filtration and precipitation* of the solid particles that are the results of burning coal and oil. Another solution is the *reduction of gaseous wastes* such as, sulphur dioxide and hydrocarbons, by more complete allotrope of oxygen of fuels. Many industries are replacing coal and oil with natural gas. Natural gas oxidizes more completely than coal and oil when it is burned properly. Thus, the combination of natural gas results in fewer waste products and less air pollution than the combination of coal and oil.

Redesigned gasolene engines— that burn fuel more completely are one of the most effective solutions to the air pollution problem. The replacement of internal combustion engines by turbine engines in motor vehicles may offer a long range solution to air pollution problems. Turbine engines burn fuel more completely, and, therefore, release fewer pollutants into the atmosphere.

13.5 Oxygen

Oxygen is the most abundant of all the elements. It is found in the air, the sea and the land. In the air, oxygen is mostly present as the uncombined element, occupying one-fifth of the volume. Some oxygen is dissolved in the water of the sea, providing fish and other living organisms in the sea with one of their means of life.

The Swedish chemist, Scheele first prepared oxygen in 1771 by heating mercuric oxide. Priestley, the well-known chemist of England, also prepared this gas. It was left to the French scientist, Lavoisier to study its properties and give it the name 'oxine' (oxygen). The symbol of oxygen is O and its molecular formula is O_2. Its atomic mass is 16.

Fig.13.5 Karl Wilhelm Scheele (1742-86). Scheele, experiment on air and combustion led him to the discovery of Oxygen in 1772.

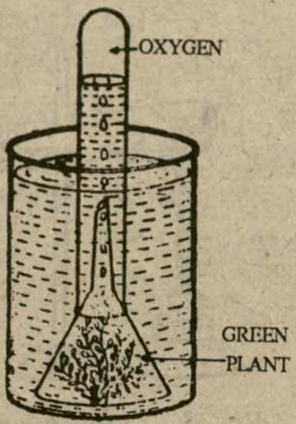


Fig. 13.6 Oxygen from green water plants.

13.6. Preparation of Oxygen

Green plants are the source of oxygen present in our atmosphere.

Experiment. Collect some green water plants and keep them in a beaker. Fill the beaker 3/4 th with water. Invert the funnel over the beaker containing the plant (Fig.13.6). Take a small test tube completely filled with water and invert it over the stem of the funnel. Expose the whole apparatus to sunlight.

After a few hours, you will observe gas bubbles start rising from the plants and are collected at the top of test tube. Put a thumb at the mouth of the test tube, while it is inside water and remove the test tube carefully. Now introduce a glowing match stick into the test tube. It will burst into a flame due to the presence of oxygen in the test tube.

1. **Laboratory Method.** In the laboratory, oxygen gas can be prepared by heating Potassium chlorate in a hard glass test tube (Fig.13.7). If Potassium chlorate is heated alone, it melts and then decomposes. When Manganese dioxide is added to Potassium

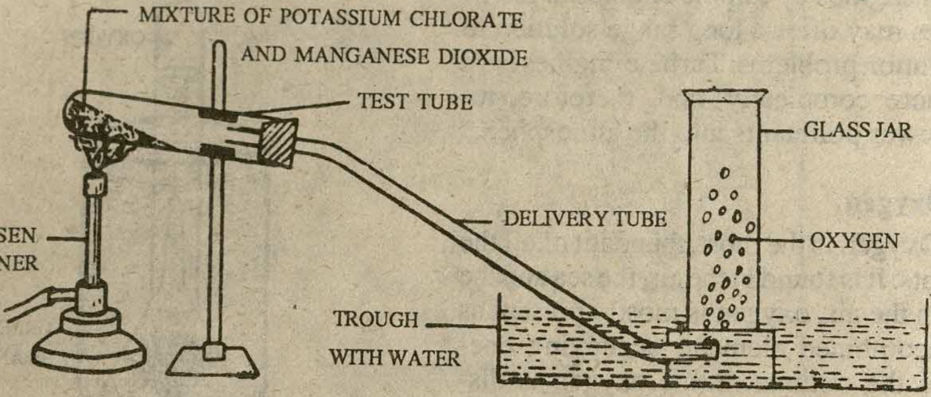


Fig.13.7 Preparation of Oxygen by heating a mixture of Potassium chlorate and Manganese dioxide.

chlorate (about $\frac{1}{5}$ th of the total weight being Manganese dioxide), oxygen is given off at a much lower temperature, 200°C instead of about 600°C and at a steady rate.

The reaction is

$$\text{Potassium chlorate} + \text{Manganese dioxide} \xrightarrow{\text{Heat}}$$

$$\text{Potassium chloride} + \text{Oxygen} + \text{Manganese dioxide}$$

$$2KClO_3 + MnO_2 \xrightarrow{\text{heat}} 2KCl + 3O_2 + MnO_2.$$

Reaction goes faster in the presence of Manganese dioxide.

Collect the gas in a gas jar by downward displacement of water. In this method MnO_2 acts as a *catalyst.*

'A catalyst is a substance which increases the rate of a chemical change without itself undergoing any permanent chemical change.'

Copper oxide and Ferric oxide will also help $KClO_3$ to give up its oxygen more rapidly. These substances are known as catalysts.

13.7 Properties of Oxygen

Physical properties. Collect the gas in several gas jars and study the following properties (*i*) colour, (*ii*) smell or odour, (*iii*) solubility in water.

We find that oxygen is colourless, odourless gas. It is slightly heavier than air and is slightly soluble in water. Aquatic plants and animals can live in water because of this property.

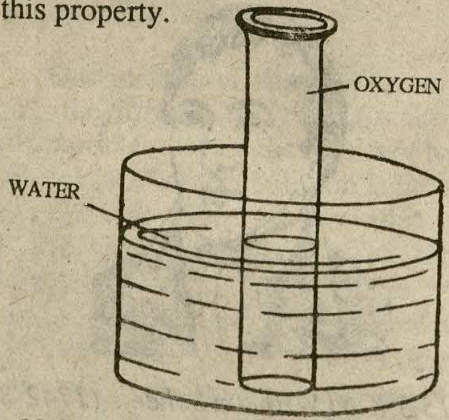


Fig.13.8 Oxygen is very slightly soluble in water.

Chemical properties :

1. Warm some sulphur in a deflagrating spoon until it begins to burn and then plunge the burning sulphur into a gas jar of oxygen. We observe that sulphur burns with a bright blue flame giving out a pungent smell.

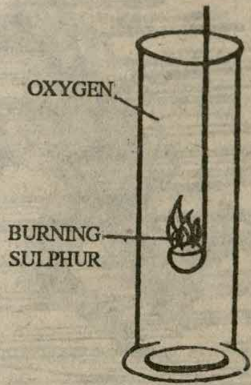


Fig.13.9 Burning of sulphur in oxygen.

$$S + O_2 \longrightarrow SO_2$$

When the reaction ceases, add a little water, put back the glass jar cover and shake the jar and its contents. Add a few drops of neutral litmus solution and notice the colour change, if any.

2. Put a small piece of phosphorus in a deflagrating spoon into a gas jar of oxygen. What happens ? The other steps are the same as those described for sulphur.

$$P_4 + 5O_2 \longrightarrow P_4O_{10}.$$

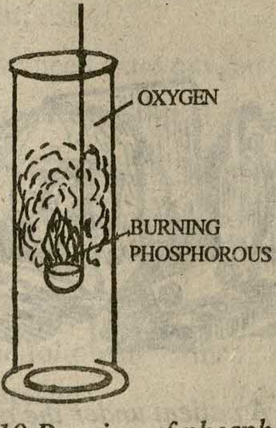


Fig.13.10 Burning of phosphorus in oxygen.

3. Place a piece of charcoal on a deflagrating spoon. Heat it red hot. When the charcoal starts glowing, introduce it into a gas jar of oxygen. Charcoal (carbon) burns more vigorously in oxygen liberating heat.

$$C + O_2 \longrightarrow CO_2 + \text{heat}$$

Add a little lime water into the jar and shake. You will observe that it becomes milky.

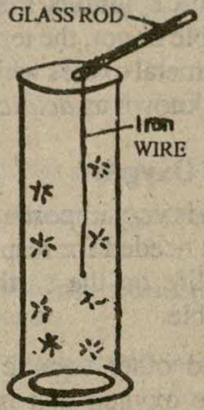


Fig.13.11 Burning of iron in oxygen.

4. Heat a small piece of sodium in a deflagrating spoon until it melts and then plunge it into a gas jar of oxygen

$$2Na + O_2 \longrightarrow Na_2O_2$$

5. As a source of iron, we use steel wool and heat it to redness before plunging it into a gas jar of oxygen.

$$3Fe + 2O_2 \dashrightarrow Fe_3O_4$$

Sodium and iron burn brightly in oxygen.

6. Do the same thing with a piece of Calcium and Magnesium and note the colour of the flame.

$$2Ca + O_2 \longrightarrow 2CaO$$
$$2Mg + O_2 \longrightarrow 2MgO$$

13.8

Solutions of the products of burning *i.e.* solutions of the oxides of the elements, turn the neutral litmus red or blue. No change is observed in the case of iron, because, the oxide in this case is insoluble in water. The non-metal oxide solutions turn litmus red and the metal oxide solutions turn litmus blue.

Litmus is known as an indicator. When it turns red it indicates an acidic solution and when it turns blue it indicates an alkaline solution.

Metal oxides, when soluble, give alkaline solutions. Non-metal oxides when soluble, give acidic solutions. For metal oxides whether soluble or not, the term *basic oxide* is used. Non-metal oxides which give acidic solutions are known as *acidic oxides.*

13.9. Uses of Oxygen

Oxygen is very important for all living beings as it is needed for respiration. Without oxygen, life on the earth would have been impossible.

Fish and other aquatic animals and plants breathe oxygen that is dissolved in water. Oxygen is essential for burning oxy-acetylene flame that is used for welding and cutting metallic plates. It is also used in industry and hospitals.

Combustion of fuels produces heat which may be converted into mechanical, electrical and other types of energy.

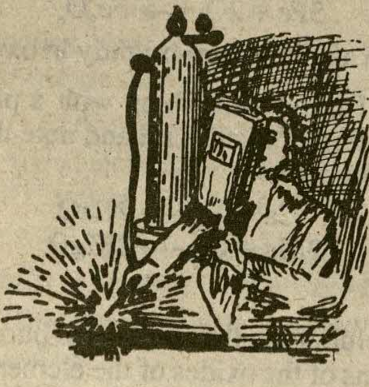


Fig.13.12 Welding by means of oxyacetylene flame.

Oxygen also finds wide use in many branches of chemical industry, like the production of acids and other important chemicals.

Fig.13.13. A diver.

There are situations in which the natural supply of oxygen for breathing is not enough. In these situations, men and women carry supplies of oxygen with them in cylinders— mountaineers at high altitudes, astronauts, submariners, divers. Certain illnesses result in breathing difficulties and patients are given oxygen to breathe, either through a mask or being put in an oxygen tent.

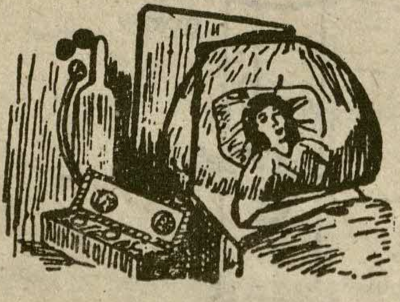


Fig.13.14 A patient under the oxygen tent.

Summary

1. Air is present everywhere around us.
2. It is colourless, odourless and tasteless and is a mixture of different gases.
3. Air is denser near the sea-level and becomes lighter as the height from sea-level increases.
4. Oxygen is the most important constituent of air.
5. In nature, it is produced by green plants.
6. It can be prepared in the laboratory by heating Potassium chlorate ($KClO_3$), Potassium permanganate ($KMnO_4$) and Potassium-nitrate ($KNO_{3)}$.
7. It is also colourless, odourless, tasteless and slightly soluble in water.
8. It is a supporter of combustion.
9. Carbon, magnesium, sodium, sulphur etc., burn in oxygen and their oxides are formed.
10. The oxides of carbon and sulphur are acidic in nature. The oxides of sodium and magnesium are basic in nature.
11. The oxygen present in air, in presence of little moisture, reacts with iron to produce rust (iron oxide) and rusting is prevented by coating the surface of iron with suitable paints.
12. Fish and other aquatic animals and plants breathe oxygen which is in dissolved state in water.
13. It is also used in industry and hospitals.
14. It is essential for burning.
15. Oxyacetylene flame is used for welding and cutting metallic plants.
16. The contamination of the air by dust, vapours etc.,is called air pollution.
17. Polluted air is unpleasant to breathe.

Questions

1. Why is air necessary for burning wood, coal etc.?
2. Give the laboratory method for the preparation of oxygen gas. Why do we use MnO_2 for this purpose ?
3. Why do we need extra oxygen supply at high altitudes ?
4. What are the two essential points about a catalyst ?
5. Name three abundantly occurring substances which contain oxygen ?
6. Explain with examples, the meaning of acidic and basic oxides. How would you obtain an alkaline solution from the burning of a suitable substance ?
7. Explain the use of oxygen in (*a*) hospitals,(*b*) mountaineering.
8. Explain the following terms :

   (*i*) Troposphere (*ii*) Stratosphere

   (*iii*) Ionosphere (*iv*) Catalyst.

9. What are the constant and variable constituents of air. List the local impurities present in air.

10. Sort out the acidic oxides and basic oxides from the list of oxides given below :

Fe_2O_3, Na_2O, PbO, CO_2, SO_3, P_2O_5, MgO, FeO

11. What is air pollution ?

12. Define the following terms :

(*a*) Alkali (*b*) Catalyst.

13. Write the equation for the preparation of oxygen from Potassium chlorate.

14. Fill in the blanks:

(*a*) Exhaled air contains more———————than inhaled air.

(*b*) $P + O_2 \rightarrow$ .... + ...

(*c*) $Mg + O_2 \rightarrow$ .... + ...

(*d*) $Ca + O_2 \rightarrow$ .... + ...

Activities

1. Oxygen is released by green plants.
2. Condensation of water vapour from air.
3. Combustion produce Carbon dioxide (Lime water turning milky).

□□

CHAPTER 14

LIFE PROCESSES—I

14.1 Introduction

You are all familiar with the basic life processes, such as, nutrition, respiration, excretion, growth, sensitivity and reproduction. These life processes are common in all living organisms irrespective of their unicellular or multicellular structures.

The question immediately comes to mind, what is behind, which helps in carrying on these life processes?

The answer behind is *energy*, which is needed for all these life processes.

All living organisms obtain this energy from *food.*

Different organisms depend on different kinds of food.

Human beings depend on plants and animals for food. You have observed many animals depending on plants, as well as, animals for food. All animals take ready to use food. Where do plants take their food from? Possibly, they synthesise the food. Let us understand how do plants synthesize food for themselves.

14.2 Photosynthesis :

Only green plants have a unique property of synthesising food on their own. They can carry on the processes in the presence of sun-light. Therefore, it is clear that food synthesis takes place in the green parts of the plant in the presence of light.

The process of food synthesis is called *photosynthesis* (Photo means 'light', synthesis means building up).

The process of food synthesis by photosynthesis involves the following steps:

Plant roots absorb water (H_2O) from the soil and transport it through stem to the leaves. Carbon di-oxide (CO_2) along with air enters into the leaves directly through the small openings (not visible with the naked eyes) present on the leaves. These openings are called *stoma* or *stomata*. It is important to mention, here, that green parts of the plant *vis-a-vis* leaves contain chlorophyll present in plastids of leaf cells. It is chlorophyll, which is needed for synthesis.

CO_2, H_2O and chlorophyll alone cannot synthesise food. Energy is needed for the synthesis.

This energy is captured from the light energy of the sun by chlorophyll. The absorbed light energy is converted into chemical energy inside the leaf cells. Ultimately, CO_2 and H_2O with the help of chemical energy synthesise the food in the form of *sugar*.

Let us see the equation for photosynthesis :

$$6CO_2 + 6H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light Energy}} C_6H_{12}O_6 + 6O_2$$

We can, thus, define photosynthesis as a buildup of sugars from CO_2 and H_2O by green plants using energy from sunlight, which is absorbed by chlorophyll.

The equation shows sugar is synthesized as food. This sugar is stored in leaves as *starch*.

Do you see O_2 is given out in the equation as a by-product ?

Yes, this O_2 is used by all living organisms for respiration.

All living beings are thus dependent on green plants for respiration.

How beneficial is the process of photosynthesis?

Let us see for ourselves that starch is synthesised in the leaves of green plants.

Activity:

Select a plant, the leaves of which have green and yellow patches. *Croton* or *Coleus* are examples of such plants.

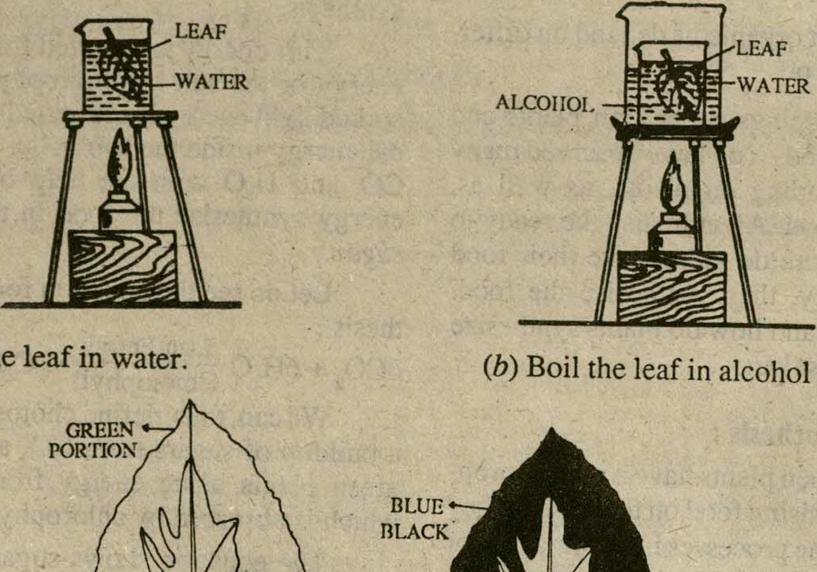
Boil the leaves in water to kill the leaf cells [Fig 14.1 (*a*)].

Now, boil the leaves in alcohol to remove the chlorophyll (caution : be careful while boiling leaf in alcohol) [Fig. 14.1 (*b*)]. The leaves become clear. Later, you put the leaves in iodine solution. The parts of the leaf, which were yellow, remained clear, and the green parts of the leaf now become blue black [Fig.14.1 (*c*)].

Don't you want to ask, how do other plants (which do not have chlorophyll) prepare their food.

Plants like mushrooms, bread-mould (*Rhizopus*) are unable to prepare their food, because they lack chlorophyll. They take their food from dead and decayed matter like rotten bread, fruits etc.

Some plants have a special method of capturing food. Their leaves are specially modified to capture insects and other small animals. These are called *insectivorous plants*. Leaves of this insectivorous plant, called, *pitcher plant*, are folded in the form of a pitcher with a lid (Fig 14.2). As the insect alights on the leaf, it gets trapped.



(*a*) Boil the leaf in water.

(*b*) Boil the leaf in alcohol in a waterbath.

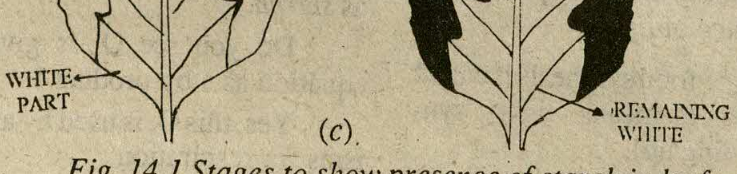


Fig. 14.1 Stages to show presence of starch in leaf.

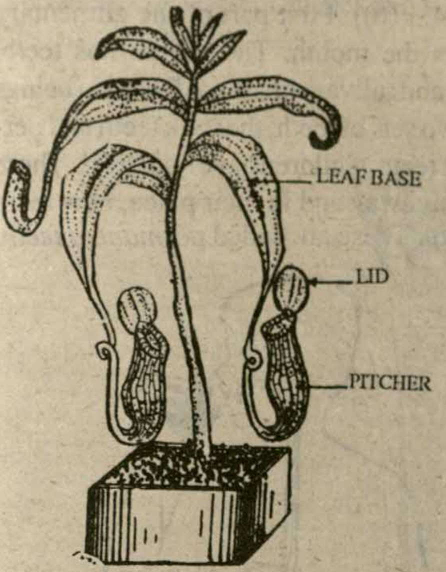


Fig. 14.2 A Pitcher plant

14.3 Types of Nutrition

Nutrition means the series of processes in the feeding of organism; the obtaining and taking in of food, the processes to which it is subjected, and its final utilisation by the organism for various purposes.

Plants take in simple inorganic substances, such as carbon-dioxide from air and water and minerals from the soil, and convert them into complex organic substances which may be oxidised to release energy or synthesized into protoplasm. This nutrition is *autotrophic*.

Animals do not have chlorophyll. They cannot make their own food and take in ready-made food either from a plant source or from an animal source. They then convert these food substances into simplersubstances which are either oxidised to release energy or are utilized to form the body structure. This nutrition is *holozoic*.

Some organisms, *e.g.*, *Mucor*, *Rhizopus* and certain bacteria, obtain food from dead organic matter either directly absorbing these substances or first digesting them outside their body and then absorbing them. Such nutrition is termed *saprophytic* and the organisms which feed in this way are called *saprophytes*.

Still some other organisms obtain their food from other living individuals. Some examples are : ringworm (a fungus) grows on the skin of the host by digesting food from there ; fleas suck the blood of the animal they live on ; tapeworms absorb digested food from the alimentary canal of the animals they live in. This mode of nutrition is *parasitic*. The organism thus feeding is a *parasite* and the organism on which the *parasite* feeds is a *host*.

Two organisms living in close association with each other, being of mutual benefit, are called *symbionts* and the condition is known as *symbiosis, e.g.*, lichens, mycorrhiza etc.

Carnivorous Animals

Animals feeding on other animals are carnivorous, *e.g.*, lion, tiger, dog etc.

Herbivore Animals

Animals feeding on plant-material are *herbivores, e.g.*, cow, goat, rabbit etc. For details, refer Section 16.1 of chapter 16 of this book.

Nutrition in Man

We all eat food. Do you know why we eat our food? What will happen, if one does not take food for sometime ? Naturally he feels hungry. What will happen, if he still

Fig. 14.3 (a) Nutrition in Man.

does not take food ? He feels weak and is not normally active. In fact, he does not have sufficient energy to do work.

People want to reduce fat from their body. What is the simple way of doing this? They reduce the quantity of their food or start fasting. This reduces the fat from their body. What has actually occurred ? The cells in the body do not grow at all or they grow improperly in the absence of food. When there is no growth, new cells are not formed.

Can you now say what does the food do for our body? Of course, food provides us energy. It helps our body to grow and to build new tissues.

What happens to food inside the body?

We all take in food. The intake of food inside the body is called *ingestion.* The food, which is taken in, is changed into simpler substances. This is called *digestion.* The change occurs in the alimentary canal. This digested food is then absorbed. The process is called *absorption.* The undigested part is thrown out of the body. This process is called *egestion.* To help in this complicated process, most animals have special system of organs, called *digestive system.* Let us study the various parts of the alimentary canal and see what happens to the food, when it passes through these various parts [Fig. 14.3 (b)]. First part of the alimentary canal is the mouth. The mouth has teeth, tongue and salivary glands. All human beings have two sets of teeth, the milk teeth and permanent teeth. Children have *milk teeth.* These teeth fall away and in their place, new teeth come up. These are called *permanent teeth.*

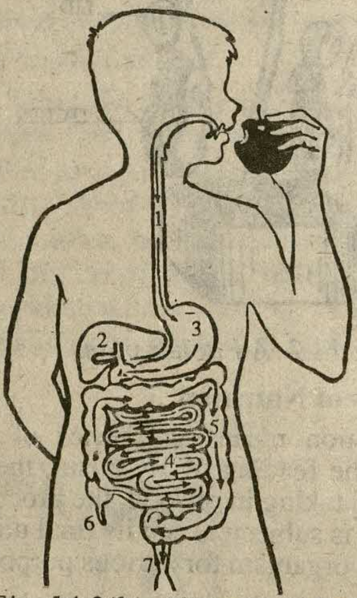


Fig. 14.3(b) Alimentary Canal

1. Oesophagus 2. Liver 3. Stomach
4. Small intestine 5. Large intestine
6. Appendix 7. Rectum

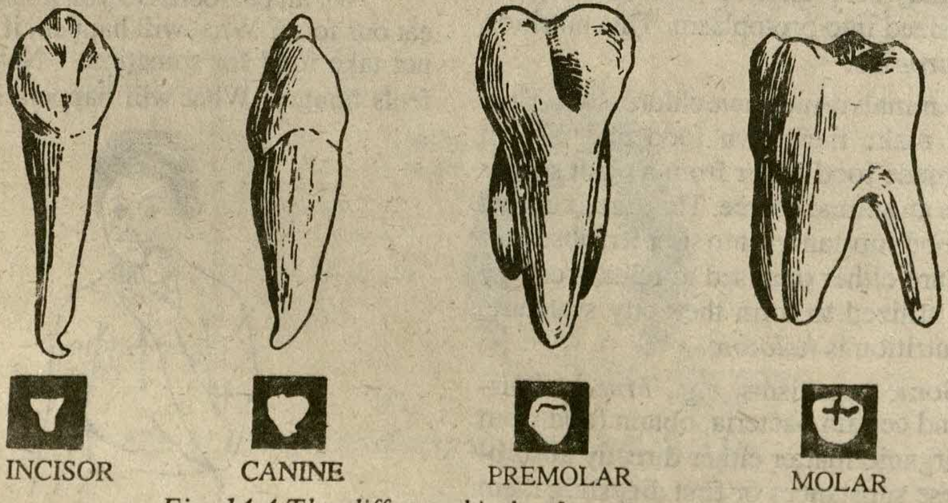


Fig. 14.4 The different kinds of teeth.

Teeth are of different shapes and sizes. (Fig. 14.4.).

They are classified as Incisors, Canines, Pre-molars and Molars. All teeth are made up of a solid tissue called *dentine*. A part of the tooth is in the socket of a jaw. It is the root. The part projecting out of the socket is the crown. It is covered by a strong layer, the *enamel* (Fig. 14.5)

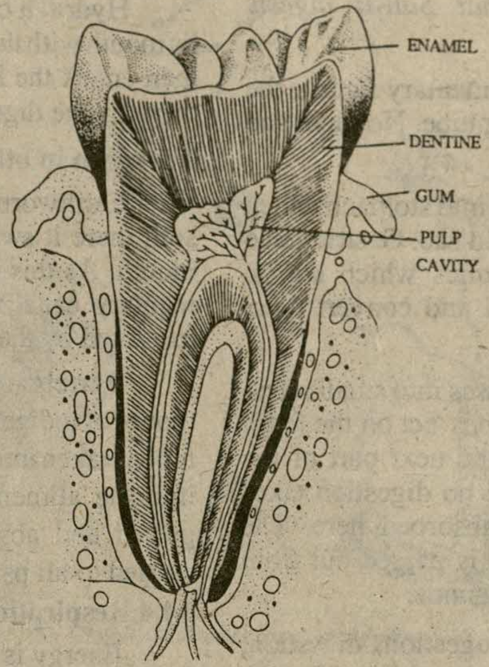


Fig. 14.5 Structure of a typical human teeth.

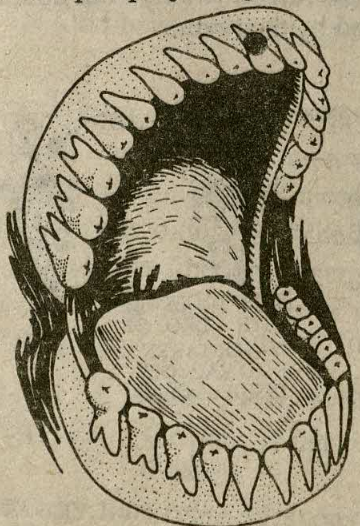


Fig. 14.6 The two jaws.

The tongue consists of several sets of striated muscles by which it moves in various directions (Fig. 14.6).

Three pairs of salivary glands are present in the mouth. They secrete saliva, which converts starch into sugar.

Activity:

Study the action of saliva on food.

Method

Collect some saliva from your mouth in a clean test tube. Make sure, you rinse your mouth before taking the saliva.

Add little bit of starch solution (you can use rice boiled water) to saliva.

Leave it for some time.

Test for the presence of starch in the test tube.

Observation : You will find *blue black does not appear*.

You conclude *that Saliva digests starch*.

Next part of the alimentary canal is the Oesophagus. It is a long tube. No digestion takes place in this part.

Oesophagus leads into stomach which is in the form of an ovoid sac. Gastric juice contains different enzymes which act on different kinds of food and convert them into simpler forms.

Next, the food passes into small intestine where more enzymes act on the food. The large intestine is the next part of the alimentary canal where no digestion takes place. Only water is absorbed here. The undigested food matter is passed out from the rectum through the annus.

The process of ingestion, digestion, absorption and egestion is achieved by different animals in different ways.

Nutrition in Amoeba and Paramaecium

Amoeba engulfs the food by throwing pseudopodia around it along with some water (Fig.14.7). The beating cilia of paramaecium force food particles into the protoplasm together with water. The food is then digested in the cytoplasm of the organism.

Nutrition in Hydra

Hydra, a coelentrate, puts the food in its mouth with the help of tentacles. The food then enters the body cavity and is digested there by the digestive juices (Fig. 14.8).

Nutrition in others :

Earthworm an Annelid, burrows in the soil, there it swallows the mud through its mouth. As this mud passes through its alimentary canal, the organic matter in it is extracted by the animal.

Vertebrates also exhibit different modes of indigesting food. In all vertebrates, food is taken into the mouth. It is then pushed into the alimentary canal, where it is digested and absorbed by the blood to be carried to all parts of the body.

14.4 Respiration

Energy is needed by living as well as non-living things to do work. Without energy they stop doing work.

Our body needs energy to carry on all its activities. Even when we are not working apparently, some organs of our body, such as the heart, brain, kidneys and lungs are working. Hence, all the twenty-four hours energy is needed by the body.

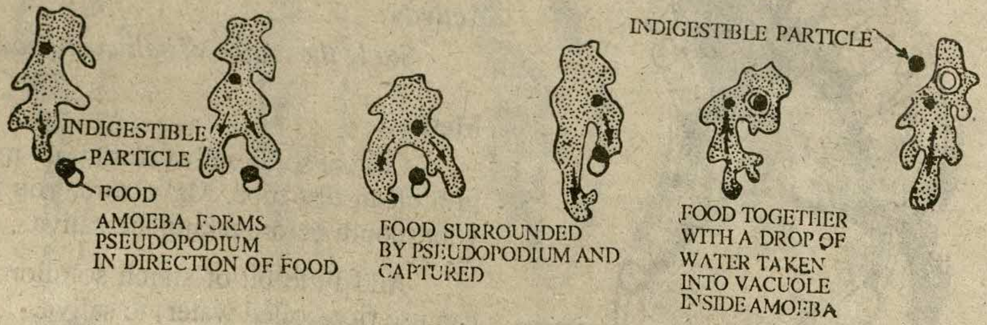

INDIGESTIBLE PARTICLE
INDIGESTIBLE
PARTICLE
FOOD
AMOEBA FORMS PSEUDOPODIUM IN DIRECTION OF FOOD
FOOD SURROUNDED BY PSEUDOPODIUM AND CAPTURED
FOOD TOGETHER WITH A DROP OF WATER TAKEN INTO VACUOLE INSIDE AMOEBA

Fig. 14.7

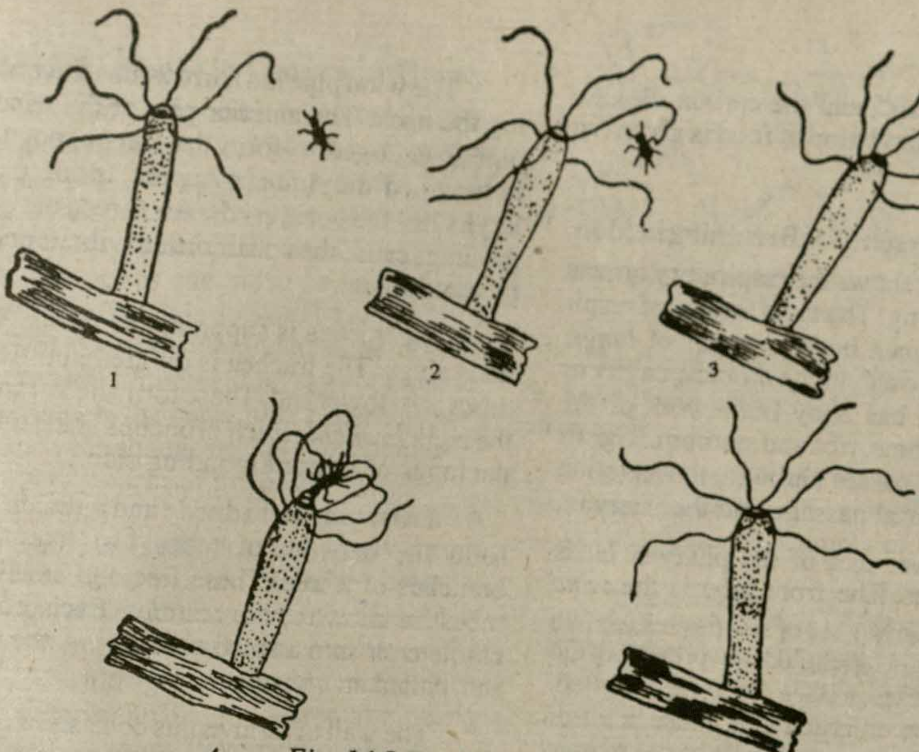


Fig. 14.8 Food catching in Hydra.

Where from do we get this energy ? You have studied in an earlier chapter that we all eat food. The foods, which we eat, contain chemical energy. During digestion the foods are broken into simpler forms in the alimentary canal. They are then absorbed by the walls of the intestine and carried by the blood to the various parts of the body. Finally, the food becomes a part of the cell matter.

The energy contained in the food cannot be used till it is released from the food. When oxygen combines with these food materials in the cells, oxidation of these food materials takes place, liberating energy and carbon dioxide and water. This is called cellular respiration.

$$C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O + \text{Energy}$$

Sugar Oxygen Carbon dioxide Water

The energy, thus, released is converted into usable form of chemical energy for the living cells. In the process, enzymes are used. In other words, to carry on this break down of sugar to release energy, enzymes play an important role. Enzymes are proteins cellular which acts as catalyst in the cell reaction. This process of respiration takes place in the living cells and is common in all organisms.

Organisms using oxygen to release energy from food carry *aerobic respiration.*

There are some organisms like parasites in man's body which release energy from food in the absence of oxygen. Such organisms are said to carry *anaerobic respiration.*

How do animals take in oxygen ? This varies from organism to organism.

The process of taking in oxygen and giving out carbon dioxide is called breathing.

How does oxygen reach the cells ? The oxygen necessary for oxidation is taken in with the help of the certain organs, called respiratory organs, and the carbon dioxide formed during oxidation of food is given out by them.

Respiratory System for Breathing in Man.

Fig. 14.9 shows the respiratory organs of a human being. The chief organ of respiration in a human body is a pair of *lungs*. These are enclosed, in the thoracic cavity or thorax, which has bony framework of the thoracic vertebrae, ribs and sternum. The air from outside passes through the external nostrils and nasal passage into the pharynx.

The lower part of the pharynx leads into two tubes. The front tube is the *wind pipe* or *trachea*. Masses of soft tissues, known as the tonsils and adenoids, are present in the pharynx. These masses become infected. They are then enlarged and cause a lot of pain. In some cases, tonsils do not give trouble.

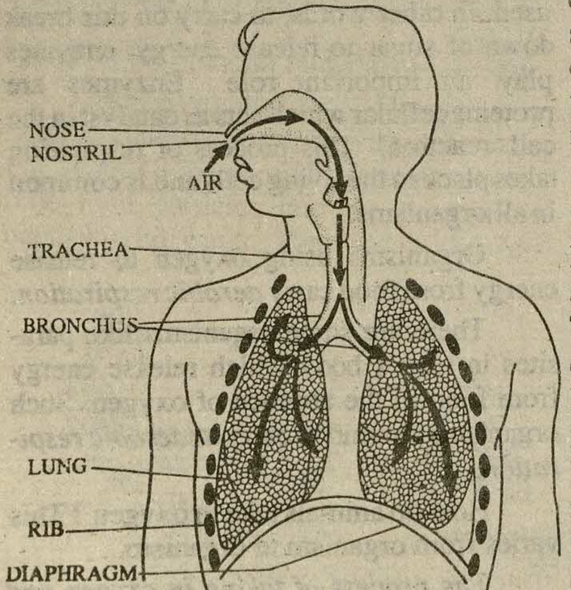


Fig. 14.9 Respiratory organs of man.

The wind pipe is a narrow tube traversing the neck. The anterior part of the wind pipe is enlarged to form the larynx, popularly called the *Adam's Apple*. Inside the larynx lies the vocal cords. Air forced out of the lungs cause the vocal cords to vibrate and produce sound.

The trachea is supported by cartilaginous rings. The trachea is divided into two tubes at its lower end. These form the left and the right *bronchi*. Each bronchus leads into the lungs of its corresponding side.

The two bronchi divide and redivide to form the network of tubes just like the branches of a tree. These fine and smaller tubes are known as *bronchioles*. Each bronchiole ends into a small chamber — the air sac, called an *alveolus*.

The wall of an alveolus consists of one layer of flat cells which on the outside is covered by a network of very fine blood capillaries. There is only one thin membrane separating the air and blood. The exchange of gases takes place by simple diffusion through the thin membranes of the capillaries and the air in the alveoli.

How many alveoli are there in a lung? There are about 300 million alveoli in each lung. They increase the absorbing surface of a lung manifold. Each lung is cone-shaped. The lung is concave at it lower surface. Why do you think it is so ? The diaphragm which bulges into the body cavity is easily accommodated. The two lungs are unequal in size. The right lung is larger than the left. The right lung has three lobes, whereas left lung has two lobes. Each lung is covered by a double layered membrane, called the *pleura*. The space between these two layers is filled with a fluid.

Gaseous Exchange in Lungs and Tissues

The atmospheric air has about 21 percent of oxygen and 0.03 percent of carbon dioxide. So, the air which we breathe in contains 21 percent of oxygen and 0.03 percent of carbon dioxide. Is the percentage of these two gases the same in the air, we breathe out ? No, it is not so. The air which is breathed out contains about 16 percent of oxygen and 4.5 percent of carbon dioxide. What changes the percentage of these gases ? Naturally the change occurs within the body. About one-fourth of the oxygen content of the air which we breathe in is utilized. This loss of oxygen is compensated by giving out about the same volume of carbon dioxide. The carbon dioxide, which is breathed out, is obtained from the blood which comes to the lungs. The nitrogen content of the air which we breathe in and breathe out remains nearly the same — about 79 percent of air.

A relaxed human being breathes about 16-18 times per minute. During exercise, this rate automatically increases, why ?

This is to break more food to release more energy which is used for exercising.

As there is a large diversity in animals according to their size, structure, place of living, etc., they respire in many different ways. According to their respiratory surface, these animals may be known as body surface breathers, skin breathers, air tube breathers, gill breathers and lung breathers.

Body Surface Breathers. Protozoans such as Amoeba and Paramaecium obtain their oxygen supply through the body surface, which consists of thin layered of cell membrane (Fig.14.10). Oxygen from the water diffuses into the body of the organism and carbon dioxide produced during oxidation of food diffuses outside the body.

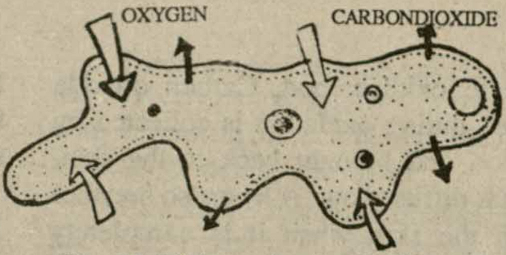


Fig. 14.10 Amoeba— a body surface breather.

Hydra, a coelenterate, also respires in a similar manner to carry on its life activities.

Earthworm is an example of skin breather (Fig.14.11). The skin of earthworm is moist. It has a rich supply of blood.

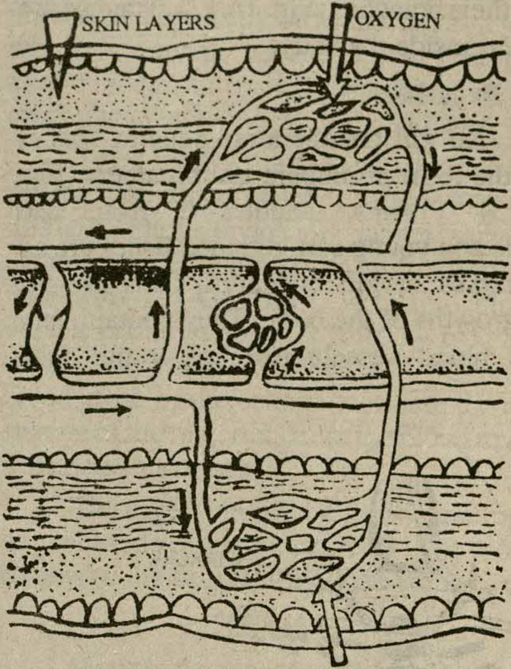


Fig.14.11 Earthworm — a skin breather.

Oxygen from air dissolves in the film of mucus and other body fluids on the skin. It diffuses into the blood plasma in solution and combine with haemoglobin. The unstable oxyhaemoglobin in blood is carried to different tissues and cells, where it releases oxygen to oxidise food. Carbon dioxide produced during oxidation is collected by the blood and brought back to the skin, when it is diffused out. A frog also breathes through the skin when it is completely immersed in water or is undergoing hibernation.

Air Tube Breathers

Cockroach, housefly, moth, etc., are air tube breathers.

The cockroach has a network of respiration tubes in its body, known as trachea and their branches (Fig. 14.12). Trachea are spread inside the body.

Gill Breathers

All gill breathers are aquatic. Fishes are the most prominent gill breathers (Fig. 14.13). Prawns, tadpoles of frogs and toads and young cartilaginous fishes are all examples of gill breathers. Gills are the outgrowths of the body. They contain very fine blood vessels just below the skin. Exchange of gases takes place by diffusion between the blood in the gills and the surrounding water.

14.5 How does exchange of gases take place in plants ?

The lower surface of the leaf has a large number of stomata. These are the openings through which exchange of gases take place in plants. For respiration, respiratory surface for the exchange of gases is essential.

14.6 Transport System Within the Body

Our body requires energy to carry on the various life activities. We get this energy from the food we eat. The food is digested in the alimentary canal. But the alimentary canal only does not require the food. It must go to all parts of the body. How does the food reach the different parts of the body, say the brain or the foot ? You may say that the digested food is absorbed into the blood in our small intestine. The blood carries the

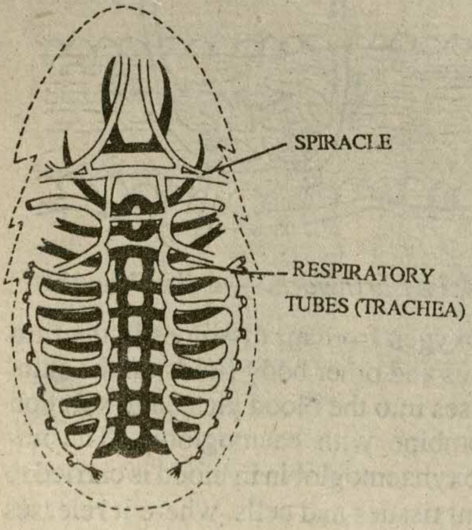


Fig. 14.12 Cockroach — an Air tube breather.

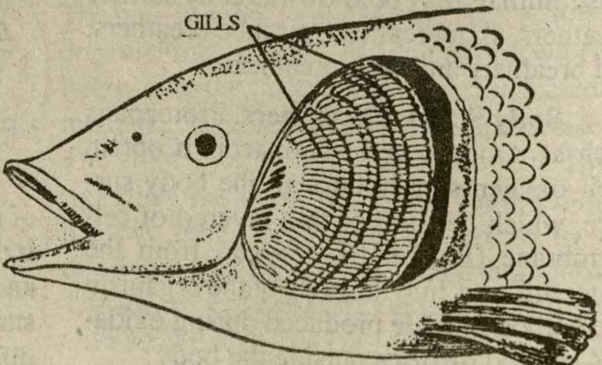


Fig. 14.13 A Bony fish — a Gill breather.

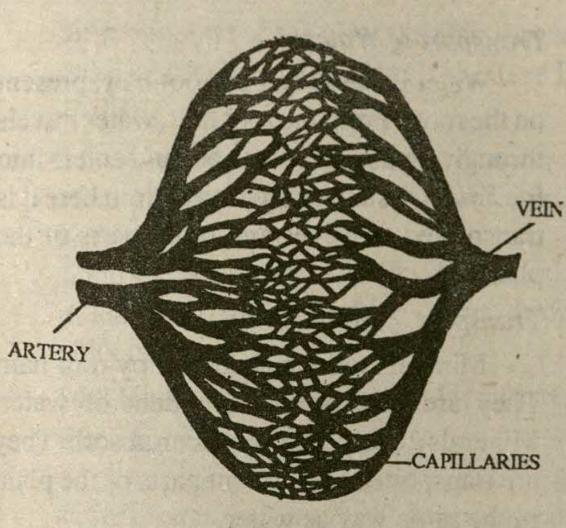


Fig. 14.14 An artery breaks into capillaries, which unite to form veins.

useful materials to different parts of the body. This is done through *Circulatory System.*

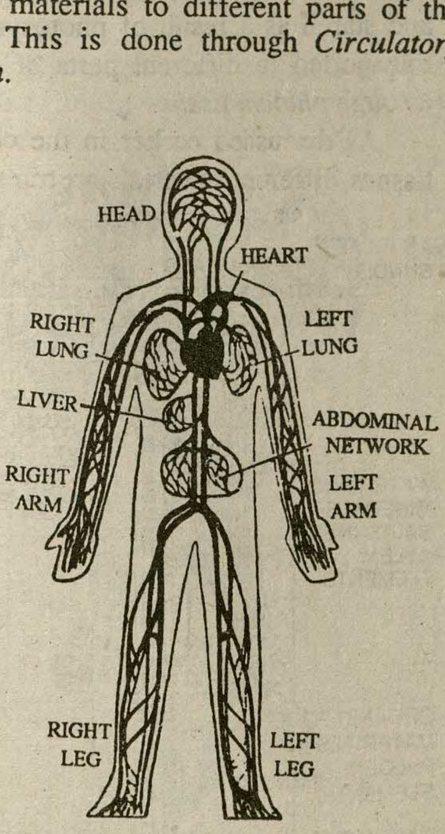


Fig. 14.15 Organs concerned with blood circulation.

Circulatory system also assists to regulate the body temperature. Hormones, secretions of endocrine or ductless glands, are also transported by the blood.

Circulatory system consists of the heart and three types of blood vessels, arteries, veins and capillaries (Fig. 14.14 and 14.15). The transporting agent is the liquid called *blood.*

The soluble and diffusible foods in the intestine must be transported to all parts of the body. This work of transport of food is done by the blood which also transports oxygen from lungs to various body parts. The waste material from the body cells are also carried by the blood to special organs so that they may be get rid of. Thus, carbon dioxide is carried to the lungs; and urea, the chief nitrogenous waste to the kidneys.

The blood is forced out of the heart through the blood vessels, called *arteries.* The large arteries divide into smaller branches in the tissues. The arteries go on dividing and redividing till they form very fine blood vessels called *capillaries* (Fig. 14.14). The capillaries pass between the cells. They bring blood close to the cells to facilitate the exchange of the materials from the blood to the cells and *vice-versa.*

The capillaries join together and form larger blood vessels, called *veins*. The blood returns to the heart through the veins.

HEART

Heart is the most remarkable organ in our body. It keeps on pumping the blood by its rhythmic contraction and relaxation throughout the life of an individual.

Position and Morphology of the Heart

Activity :

Examine the chart showing the heart in the human body. Observe in what part of the body it is situated.

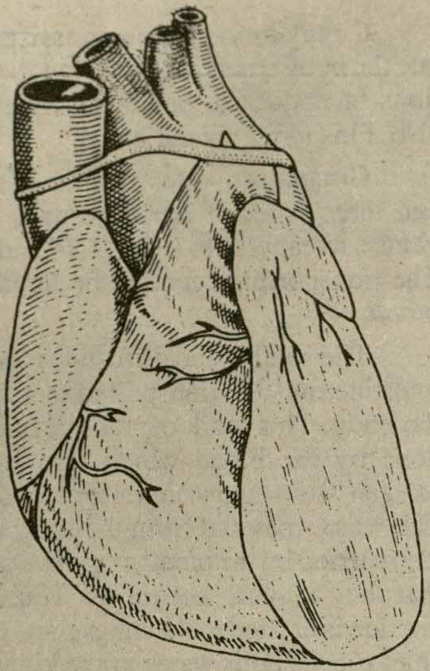


Fig. 14.16 External view of the human heart.

The heart is located more or less in the central part of thorax. It is behind the sternum between the two lungs and a little towards the left side. The heart is more or less of the size of a clinched fist of an individual.

Demonstration. Your teacher will show you the heart of a sheep. Compare it with the model of the human heart in your laboratory.

The heart (Fig. 14.16) is a muscular organ. It is enclosed in a double-walled sac called pericardium. A fluid is filled between these two layers. This fluid provides protection to the heart against shocks and friction and renders its working much easier. In the body, heart contracts and relaxes in a definite cycle. A short pause of rest follows each contraction.

14.7 How does transport of materials take place in plants ?

Unlike animals, plants have a very simple system of transportation of materials to different parts.

Transport of Water:

Water is absorbed by root hair, present on the roots. From the root hair, water travels through the tissues of the root and enters into the *Xylem tissues* of the stem. From here it is transported to leaves and other parts of the plant.

Transport of Minerals:

Minerals too are absorbed by root hair. They are absorbed independent of water. Minerals dissolved in water can absorb. They are transported to different parts of the plant in the same way as water.

Transport of food synthesized in leaves:

The food synthesized in leaves as sugar and starch as a result of photosynthesis is transported to different parts of the plant through *phloem tissue.*

As discussed earlier in the chapter of tissues, different materials are transported to

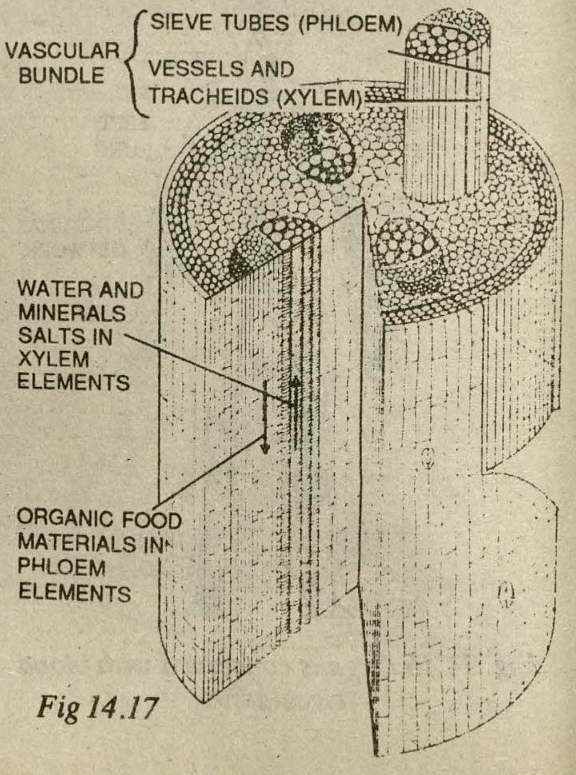

VASCULAR BUNDLE
SIEVE TUBES (PHLOEM)
VESSELS AND TRACHEIDS (XYLEM)
WATER AND MINERALS SALTS IN XYLEM ELEMENTS
ORGANIC FOOD MATERIALS IN PHLOEM ELEMENTS

Fig 14.17

different parts of the plant through *Vascular bundles* present in the plant body. (see Fig. 14.17)

↑Shows the transport of water and minerals to all parts of the plant through Xylem.

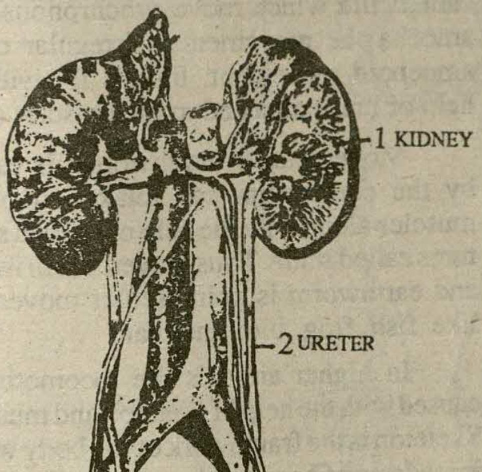
↓Shows the transport of food synthesized in leaves to all parts of the plant through phloem.

14.8 How does body get rid of its wastes ?

Excretory Systems

Excretion is the removal of metabolic waste matter from the body. The removal of the undigested food materials as the faeces is not excretion, because the undigested food has not undergone any metabolic activity at any stage.

The chief waste products are carbon dioxide, nitrogenous wastes, such as urea and water. Urea is the chief nitrogenous waste product. It is formed by the liver which converts harmful nitrogenous products into harmless urea. Carbon dioxide and some water vapour are given out during the exchange of gases. The nitrogenous waste products dissolved in water are carried by the blood to kidneys (Fig. 14.18). The water containing these wastes and the excess of salts are filtered through the fine tubules in the kidney. Excretion helps in the removal of wastes from the body.



1. Kidney. 2. Ureter. 3. Bladder

Fig. 14.18 The Principal organs to help excretion.

14.9 Excretion in Plants

Plants have no special system of excretion. The waste product of respiration, carbon dioxide is partly used for photosynthesis. The excess carbon dioxide escapes through the stomata. We have often observed trees shedding leaves and barks. Some waste products get accumulated in barks and leaves. These are got rid of along with them. Some products are transformed into harmless products and stored inside the plant body. In older plant cells, large vacuoles contain excretory products which remain inside the plant body for its whole life. Plants secrete a number of products; some of the secretory products of plants are gum, latex, resin, etc.

14.10 Movement

Movement is the important characteristic of life. It is found in all the plants and animals. You must have observed that various living organisms move from one place to another. For example, a bird flies, a dog runs, an earthworm crawls.

The animals move from one place to another in search of food, shelter and also to save themselves from enemy. Hence, they are provided with various locomotory structures.

In plants, on the other hand, the displacement from one place to another is not observed because of their characteristic mode of nutrition. The plants show movement in the form of slight curvature while remaining fixed to the ground.

Movements can be broadly classified into two types as *locomotion* and *movement of curvature*. Locomotion is the movement in which a living organism moves physically from one place to another. This locomotion is observed mostly in animals, *e.g.*, flying of the butterfly, running of a child, etc. Body does not necessarily has to move from one place to another to show movement. There are various other movements going on all the time in our body. Our stomach shows a type of movement when food is taken in; similarly the heart is beating all the time.

Most of the plants show only the movements of curvature. Movements in plants may be due to unequal growth on any side of the organ of the plant. This kind of movement is seen in some creepers and twiners. Movement in plant may be due to contact as seen in case "Touch-me-not", whose leaves get folded when touched. Light and gravity also produce movement in the plants as seen in the following experiments. Such movements brought about the response to external stimuli are called *taxis*. Such movements in response of light are *phototaxis*. *Geotaxis* is a movement in response to face of gravity.

Experiment (*a*): Keep a potted plant near the window of a room which is the only source of light for the room. After a few days it is seen that stem of the plant bends towards light (Fig.14.19). This is called *phototropism*.

Animals have various organs to help them in locomotion. The lower animals have simple structures for locomotion, while higher animals have more complex structures. Lower animals usually move with the help of thread like structure called *flagella* (*sing*. Flagellum) which produces whip-like movement thus causing locomotion, *e.g*., Euglena. In paramaecium, movement is caused by numerous hair-like structures called *cilia* which move synchronously. In amoeba the movement is irregular called amoeboid movement. Insects fly with the help of lungs attached to the muscles only.

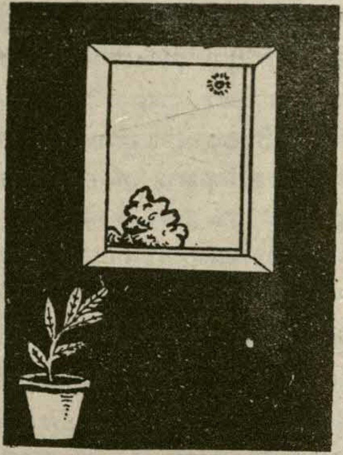


Fig. 14.19 The tip of the stem turns towards the source of light.

Movements in earthworms is caused by the contraction and relaxation of the muscles along with the help of special structures called *setae*. Thus,movement in insects and earthworm is unimuscular movement, like fish, frog, bird and man.

In higher animals the locomotion is caused with the help of skeleton and muscles. Skeleton is the framework of the body which is made up of bones and cartilage. The bones provide certain stiffness and give the definite and characteristic shape to the body. Skeleton provides surfaces to which muscles are attached and thus helps in locomotion. In our body there are about 206 bones.

Muscles are responsible for the movement of various organs of the body. Most of them are attached to the bones at one or both ends The attachment may be direct or through a tendon which is a band of inelastic connective tissue.

Movement in Man

Muscles are usually arranged in antagonistic pairs (flexors and extensors) which cause opposite movement (Fig. 14.21). *Flexors* bend a joint while *extensors* straighten it. The muscles which cause movement of bones are called the *skeletal muscles or striated muscles*. It is the bones and muscles which help us to move our body while walking and running.

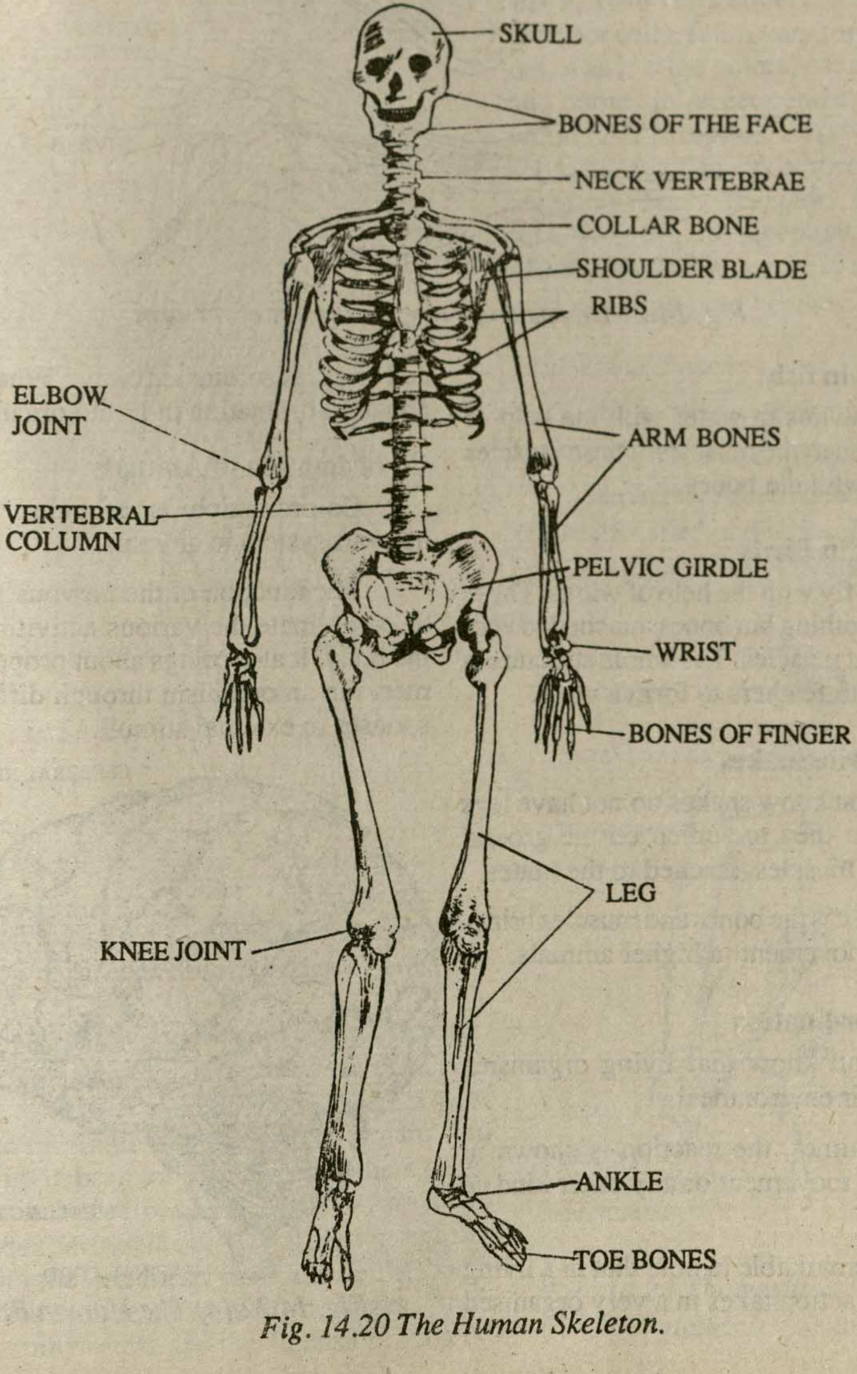


Fig. 14.20 The Human Skeleton.

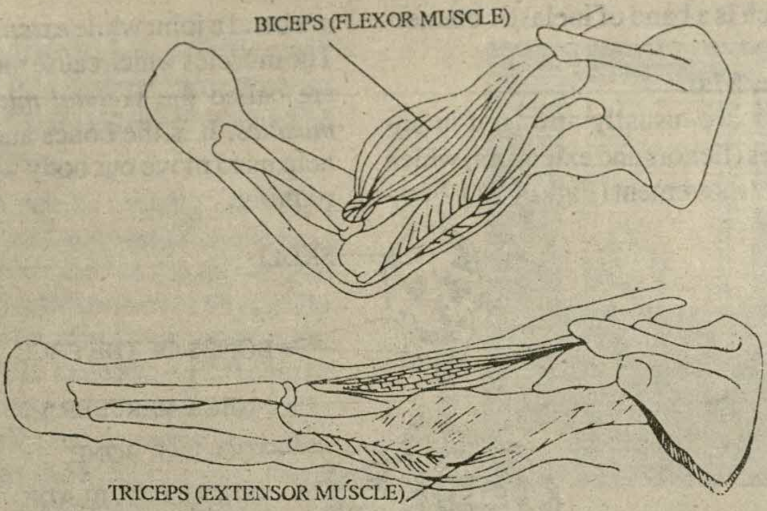


Fig. 14.21 Biceps and Triceps muscles of the arm.

Movement in fish

Fish swims in water with the help of fins, attached to the muscles. These muscles are joined with the bones.

Movement in Birds

Birds fly with the help of wings. These wings are nothing but bones attached to very strong flight muscles. The whole structure is covered with feathers to form a wing.

Movement in Snakes :

Do you know snakes do not have legs to walk, but they too creep on the ground the help of muscles attached to the bones.

Thus, it is the bones and muscles bringing about movement in higher animals.

14.11 Co-ordination

You all know that living organisms react to their environment.

Sometimes, the reaction is shown in the form of movement or any other kind of action.

It is remarkable to note that in a living body every action takes in a very organised and well co-ordinated way. What brings about co-ordination in living organism ?

Co-ordination in Animals

Co-ordination is brought about by nervous system in animals.

The function of the nervous system is to co-ordinate the various activities within the body. It also brings about proper adjustments in an organism through different responses to external stimuli.

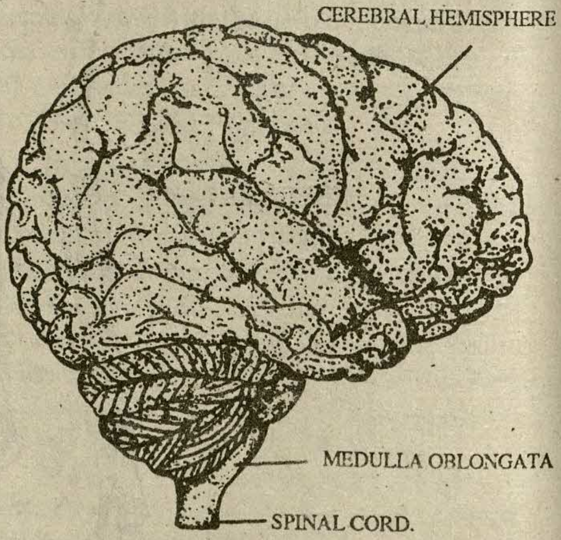


Fig. 14.22 (a) The Human Brain.

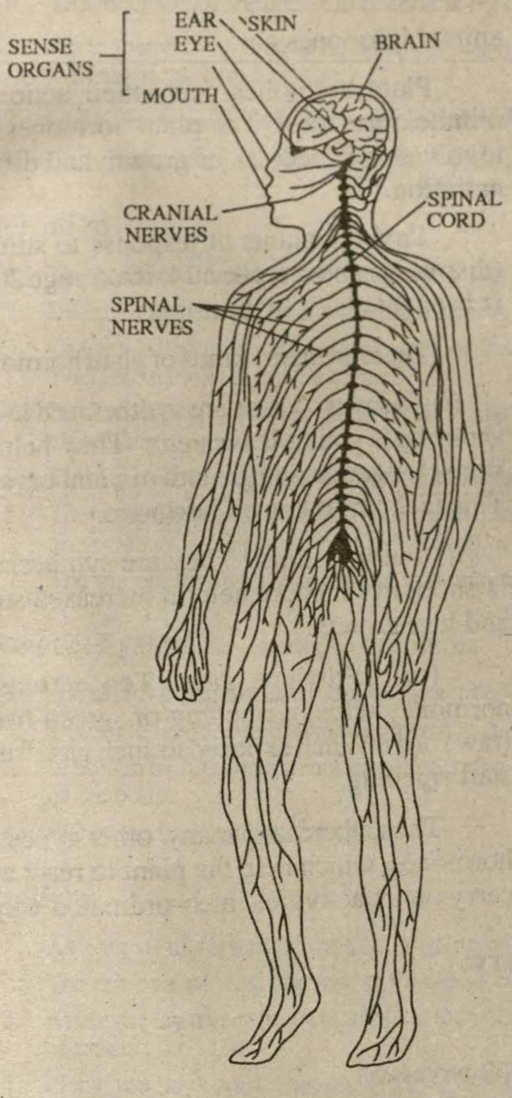


Fig. 14.22 (b) The parts of the Human peripheral and central nervous systems.

Nervous system consists of the brain, spinal cord and a large number of nerves [Fig. 14.22 (*a*) and Fig. 14.22 (*b*)]. Some of these originate at the receptor organs and end up in brain or spinal cord. Others originate in brain or spinal cord and travel to various parts of the body. All the nerves form a complicated mesh work inside the body. Nerves are the carriers of messages. Brain and spinal cord are the 'decision makers' and receptor organs or cells are the places that receive a particular message from the external or internal environment. Eyes, ears, nose, taste buds are important receptor organs that receive stimuli like light, sound, smell, taste respectively. Skin has various receptor cells. It is a very important sensory organ as it is the outer most part of our body and comes in direct contact with the outer world. All receptors are specialised nerve cells. Some of the skin receptors, are Pain receptors, Touch receptors, Pressure receptors, Temperature receptors, etc. If the skin did not have these, it is easy to imagine, how difficult life would become.

Endocrine System

This system too helps in bringing about Co-ordination in our body.

There are some glands or tissues , in our body called endocrine glands as shown in Fig. 14.23. These glands secrete chemi-

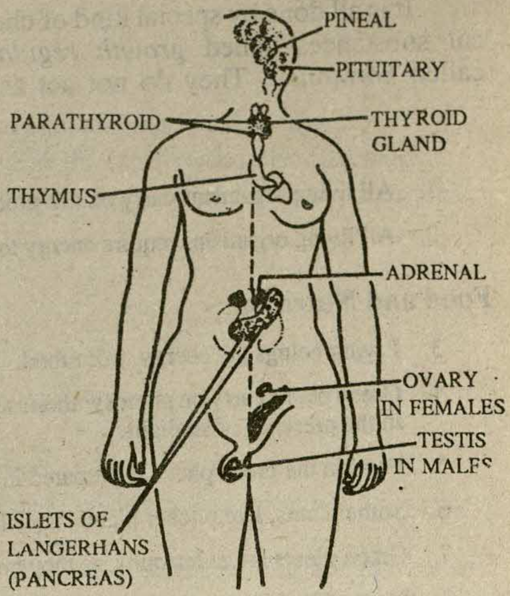


Fig. 14.23 The position of the endocrine glands in human body.

Co-ordination

1. All living organism function in a very well co-ordinated manner, within their body or with the environment.
2. Animals have well developed organs like brain, spinal cord and nerves which bring about co-ordination.

   Some animals may only have *receptor cells* helping in the function.
3. In animals endocrine system too brings about co-ordination along with nervous system.
4. Plants bring about co-ordination with the help of specific chemical substances called *growth regulators* or *hormones*. A very common plant hormone is auxin.

Questions

1. In the following, name the (*a*) System and (*b*) Organs involved in human beings.

   1. Digestion 2. Respiration 3. Excretion 4. Circulation.
2. Write the equations representing photosynthesis and respiration.
3. Give some examples of the following kinds of categories :

   (*i*) Autotrophs (*ii*) Insectivores (*iii*) Saprophytes
   (*iv*) Herbivores (*v*) Carnivores.
4. What is the advantage of the following :

   (*i*) Transport system (*ii*) Excretory system
   (*iii*) Respiratory system (*iv*) Co-ordination
   (*v*) Digestive system (*vi*) Endocrine system
   (*vii*) Locomotion.
5. Define the following :

   (*i*) Ingestion (*ii*) Excretion (*iii*) Growth
   (*iv*) Taxis (*v*) Cellular respiration (*vi*) Breathing
   (*vii*) Hormone (*viii*) Movement of curvature.
6. Explain with the help of a diagram, the mechanism of taking in of food in amoeba.
7. How is co-ordination brought about in plants ? Name a plant hormone.
8. Name the different phases involved in cellular development.
9. What do the following examples show ?

   (*i*) Folding of leaves in 'touch-me-not'
   (*ii*) Use of Ethylene gas.
   (*iii*) Leaf of a plant after boiling in alcohol, turns blue black when put in iodine solution.
   (*iv*) Bending of plant towards light, when kept in a dark room.

10. What makes :

(*i*) Chlamydomonas move (*ii*) Fish breathe

(*iii*) Leaf green (*iv*) Amoeba reproduce

(*v*) Digestion of food takes place.

11. What happens to the energy released as a result of oxidation of food ?

12. What are aerobes ?

13. What is anaerobic respiration ?

14. What is blood made up of ?

15. Name the muscles which help you

(*i*) bend your arm (*ii*) Straighten your arm

16. Plants do not move from one place to another, why it is considered essential in animals ?

Activities

1. Draw the diagram of some common animals showing how do they take in food.
   1. One herbivore 2. One carnivore 3. Bird picking up grains.

2. Ask your teacher to help you to count your breathing rate.
   1. While sitting down.
   2. After walking for 15 minutes.
   3. After running fast for 15 minutes.

3. Blow your breathed air into lime water contained in a beaker with the help of a straw. (Make sure you do not suck in lime water) Lime water turns milky when it comes in contact with carbon dioxide.

4. Perform an experiment to show that energy in the form of heat is given out during respiration.

Take seeds weighing few gm. Put them on soaked cotton for a day in the light. Young seedlings of plants emerge out of the seeds. Put these young seedlings in a thermos flask.

Cover the mouth of thermos flask, and insert a thermometer into the flask containing young germinating seedlings.

Record the temperature, while putting the thermometer in the flask and after 2 hours from keeping in the flask.

Discuss the change in temperature with your teacher.

5. Find out the different excretory materials given out :
   1. In plants
   2. In animals.
6. What different body systems are involved, when you are:
   1. Exercising
   2. Sleeping.
7. Observe a drop of water from pond under the microscope. Note down what you see.

□□

CHAPTER 15

LIFE PROCESSES—II

We have talked about the life processes in the previous chapter, which help the organism to remain alive.

No organism has limitless life, all organism must die sooner or later. We shall now talk of the life process that helps in continued existence of life.

15.1 Reproduction

Reproduction is the function by which all living organisms add new individuals to the population. It is an answer to death. Death may take away the individual but the individual maintains his continuity through reproduction.

15.2 Types of Reproduction

Living organisms reproduce in different ways. Reproduction may be grouped under two categories :

1. Asexual reproduction, and
2. Sexual reproduction.

In the asexual reproduction, one individual multiplies ; but, in sexual reproduction, the offspring arises from the fusion of two cells, each contributed by one of the parents.

Asexual Reproduction

Different methods of asexual development are seen in the plants and animals world.

(*a*) *Fission*. As the individual grows into a certain size, it divides into two (Fig. 15.1). The nucleus first divides and is followed by the division of the cytoplasm.

The best example is Amoeba and Bacteria. When fission results into two, it is called '*Binary fission*'. Some times, the

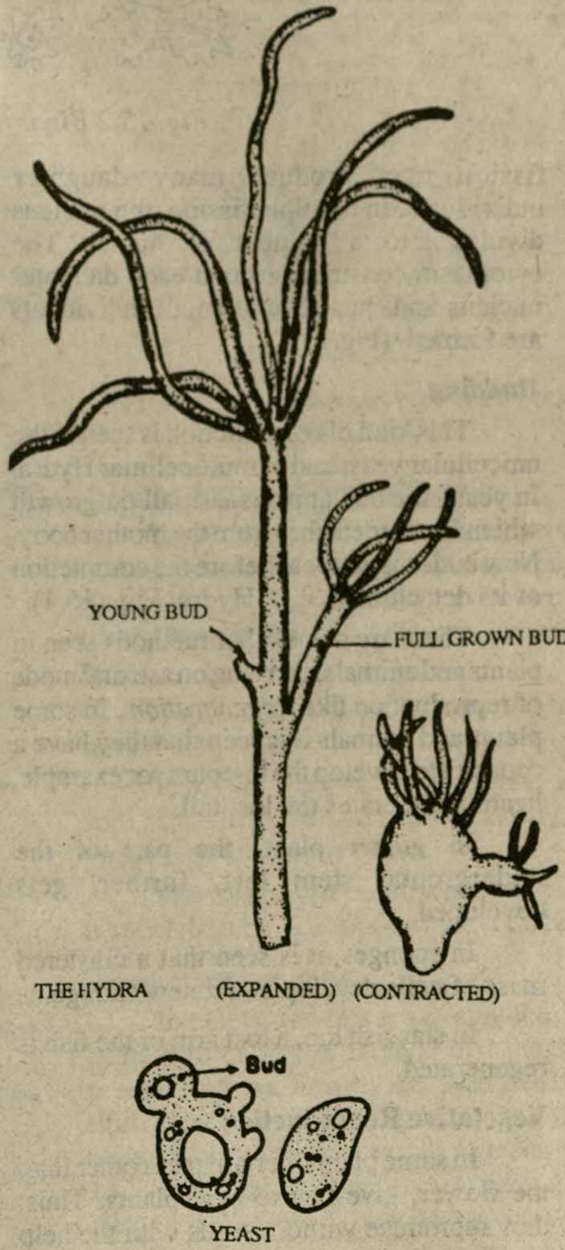


Fig. 15.1 Budding in Hydra and Yeast.

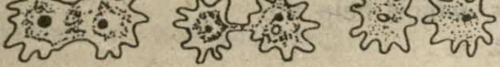


Fig. 15.2 Binary fission in Amoeba

fission may produce many daughter individuals. In multiple fission, the nucleus divides into a number of nuclei. The cytoplasm constricts around each daughter nucleus and thus several small individuals are formed (Fig.15.2).

Budding

This kind of reproduction is seen in the unicellular yeast and in multicellular Hydra. In yeast, the bud appears as small outgrowth which finally detaches from the mother body. New buds may appear before the completion of its detachment, *e.g.*, Hydra Fig. (15.1).

There are some other methods seen in plants and animals, carrying on asexual mode of reproduction like *Regeneration* . In some plants and animals it is seen that they have a capacity to develop the lost part, for example, lizard regenerates the lost tail.

In ginger plant, the part of the underground stem lost, further, gets developed.

In sponges, it is seen that a clustered mass of cells develop into a new sponge.

In star fish too, a lost arm of the fish is regenerated.

Vegetative Reproduction

In some plants, certain parts other than the flower, give rise to new plants. Thus, they reproduce without seeds with the help of some vegetative part of the plant. This type of reproduction, is called *vegetative reproduction.*

Vegetative Reproduction by Stems

Experiment. Cut a potato tuber in pieces in such a way that each piece has at least two or three eyes on it (Fig. 15.3).

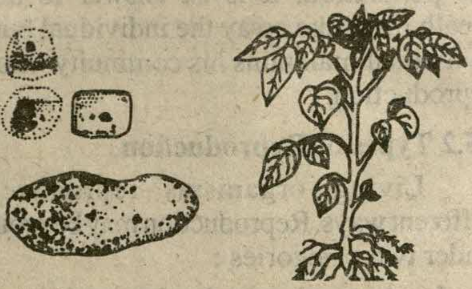


Fig. 15.3 Potato tuber reproduces vegetatively.

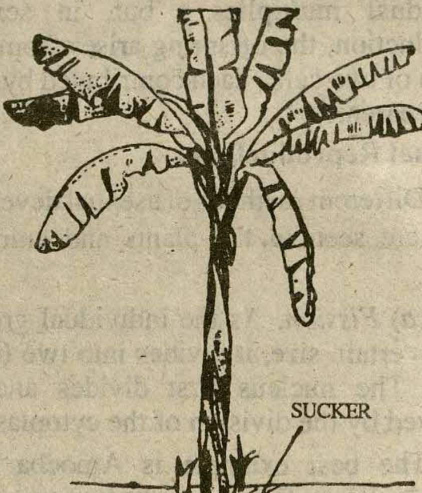


Fig. 15.4 Banana reproduces vegetatively by means of stem.

Place these pieces in a flower pot containing a mixture of moist sand and saw dust. Keep the mixture moist. Keep the flower pot under observation.

In about 10 days time some of the 'eyes' sprout to form new plants.

Experiment. Observe a plant of Canna or Banana (Fig. 15.5).

The plant has a green aerial stem with leaves. It also has a stocky underground stem. From the underground stem small shoots arise. Each of these shoots forms a small plant. If this plant is separated from the mother plant and planted elsewhere, it develops into a new plant. Banana and Canna have almost lost the power of reproducing by seeds.

Experiment. Observe the plant wood sorrel *(Oxalis)* (Fig. 15.6) or the growing grass in a lawn. How does it grow ?

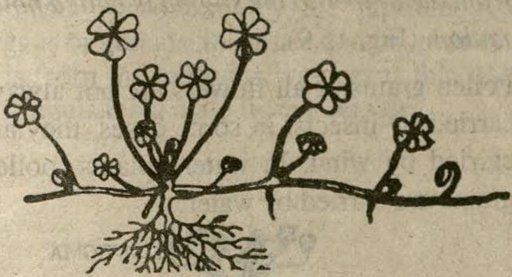


Fig. 15.6 Runner of wood sorrel (Oxalis).

Vegetative Reproduction by Leaf

Experiment. Place a Bryophyllum leaf (Fig. 15.7) on moist sand in a dish. Put some small stones on the leaf to keep the margin of the leaf in touch with the moist sand. Observe what happens in a few days.

Small plants with fine roots and shoots come out from the notches of the leaf.

Separate a small plant from the leaf. Plant it in soil. Observe what happens.

In a few days, the small plant becomes fixed in the soil. It develops into a mature plant.

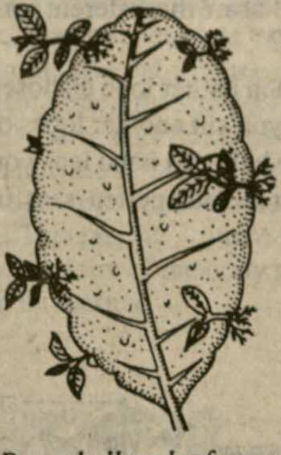


Fig. 15.7 Bryophyllum leaf reproduces vegetatively.

Vegetative Reproduction by Roots

Experiment *:* Take the thick, swollen roots of sweet potato or asparagus or tapioca. Place some of these roots in a flower pot containing moist soil. Observe for a few days.

New plants will grow from the roots buried in the soil.

Thus, we have seen that roots, stem and leaves can be used in increasing the population of various plants.

The time taken for new plants to form is much less by this mode of reproduction.

Sexual Reproduction

In plants, flowers are among the most beautiful creations of nature. But to the plants producing them, flowers are more than beautiful creations. A flower is a specialized organ which reproduces the species (Fig. 15.8). Flowers may be bisexual (hermaphrodite) or unisexual. As you know, the flower consists of the male and reproductive parts *stamens* and *carpels* respectively. These parts of the flower are involved in the sexual reproduction. The stamens of a flower constitute the male sex organs.

What are the different components of a stamen ?

Each anther lobe encloses two pollen-sacs. If you cut another lobes of lily and see with the help of a hand lens you will be able to observe four pollen sacs in two anther lobes.

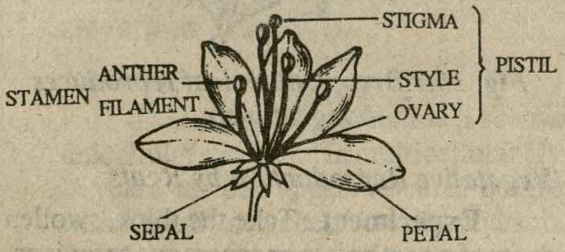


Fig. 15.8 Structure of a typical flower.

In each pollen sac, there developes *pollen grains* . Each pollen grain is a carrier of a male sex cell called a *male gamete.*

The carpel of a flower constitutes the female sex organ of a plant.

What is the swollen lower end of the carpel called ?

If you split open the *ovary* what do you see ?

These round pin head size structures in the ovary are called *ovules.*

Each ovule is a carrier of a female sex cell called a *female gamete* or *egg.*

The sexual reproduction in plants would take place only if the male gamete would fuse with the female *i.e.*, pollen grain should reach the carpels for letting this fusion takes place.

When the flowers are in bloom, we observe many insects, such as butterflies, moths, bees visiting them. What are these insects doing ? You may say that they are taking nectar or honey from the flower.

Experiment. Catch an insect immediately after it has visited a flower. Dust its body on the paper with a fine brush. Examine the paper with your hand lens.

Do you find anything on the paper which has fallen off from the body of the insect, when you dust it ?

There are small round structures. These are the pollen grains, which were deposited on the body of the insect when it went to the flower to suck the nectar or honey. Subsequently the insect would deposit the pollen grains on the sticky stigma of the other flower during the visit for the same purpose.*The transference of pollen grains from the anther to the stigma is called pollination.* (Fig. 15.9).

Pollen grains of all flowers are not always carried by insects. In some cases, they are carried by wind. In water plants, pollen grains are carried by water.

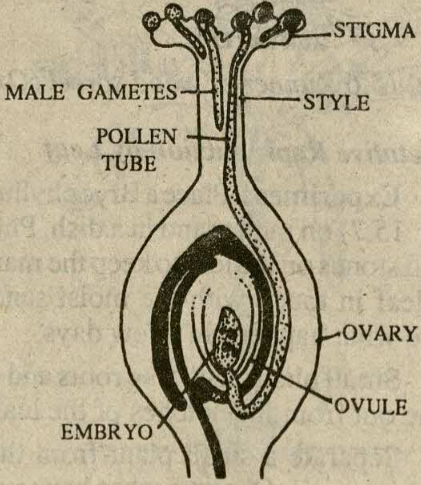


Fig.15.9. Reproduction in a flower.

When the male cell fuses with the egg cell in the ovule, *zygote* is formed. The fusion of male and female cell is called *fertilization.*

Can you think what happens to the different parts of the carpel after fertilization ? After pollination and fertilization the flower shows some remarkable changes in its structure. The petals, stamens, style and stigma wither and generally fall off. The calyx may either fall off or may remain intact in a dried and shrivelled form. The ovary enlarges to form a fruit, with the ovary wall becoming dry and hard, or succulent and fleshy. It may contain one or many seeds developed from the ovules in the ovary.

In Animals

Human beings also reproduce, but only through the sexual method, in which there is a fusion of the reproductive cells, or the gametes produced by the reproductive organs or gonads, the testes and the ovaries. It is from the reproductive organs that one distinguishes a male from a female.

The Male Reproductive System

The male reproductive organs are a pair of testes, whose function is to produce the male reproductive cells or spermatozoans (Fig.15.10). Testes, though developed in the abdominal cavity, shortly before or after birth descend into the scrotal sacs which are loose pouch-like structures situated in the pubic region. This facility is there because the higher temperature of the body prevents the formation of sperms.

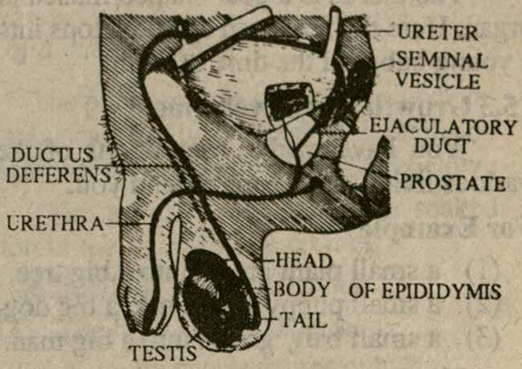


Fig. 15.10 Human reproductive system : Male.

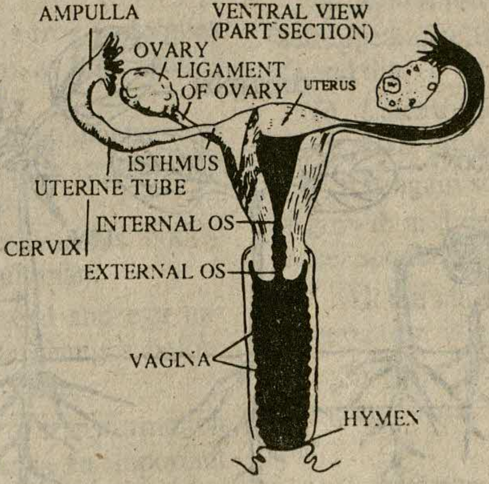


Fig. 15.11 Human reproductive system : Female.

(2) Plant produces flowers in the same season.

(3) Flowers after fertilization produce fruits and then seeds.

(4) After the seed formation the plant dies. These are called *annuals*.

There are plants like the big trees of Neem, Mango, Guava, etc., — it is seen that

(1) The seed develops into a plant.

(2) The plant grows into a tree with the regular growth of the meristematic region.

(3) Flowering takes place.

(4) Fruits are formed and afterwards seeds are formed.

After every season the phenomenon of flowering and fruiting is repeated.

Such plants continue to grow for years and are called *perennials*. They show growth for many years.

The phenomenon of growth and development in other groups of plants is also observed.

(1) In organisms like chlamydomonas the cells increase in size to show the growth.

This shows that growth is a cellular process.

(2) In *fungi* — example *Rhizopus* (bread fungus) — Inert round dark brown and black bodies called *spores* when fall on *moist bread* kept in a warm dark place germinate into the filaments of Rhizopus.

(3) In mosses and ferns also the phenomenon of development is very well developed (Fig.15.14).

(*i*) Here the main plant body of fern produces spores.

(*ii*) These spores germinate into a special body called a *gametophyte* — this produces gametes — male and female.

(*iii*) Gametes fuse and then form the spore producing plant body — the *sporophyte* .

Sporophyte stage alternates with the gametophyte and this phenomenon is called *alternation of generation.*

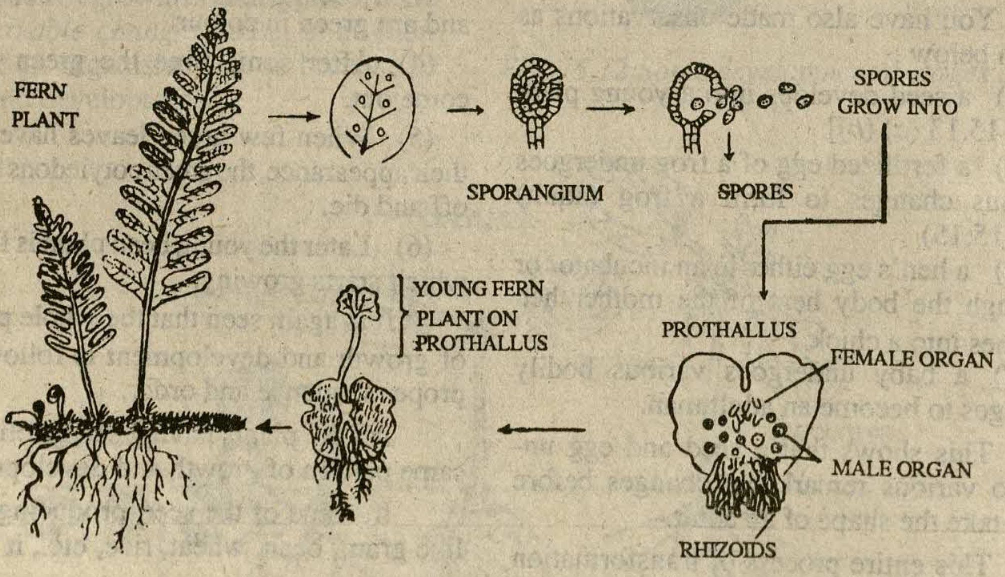


Fig. 15.14. Alternation of generation in fern.

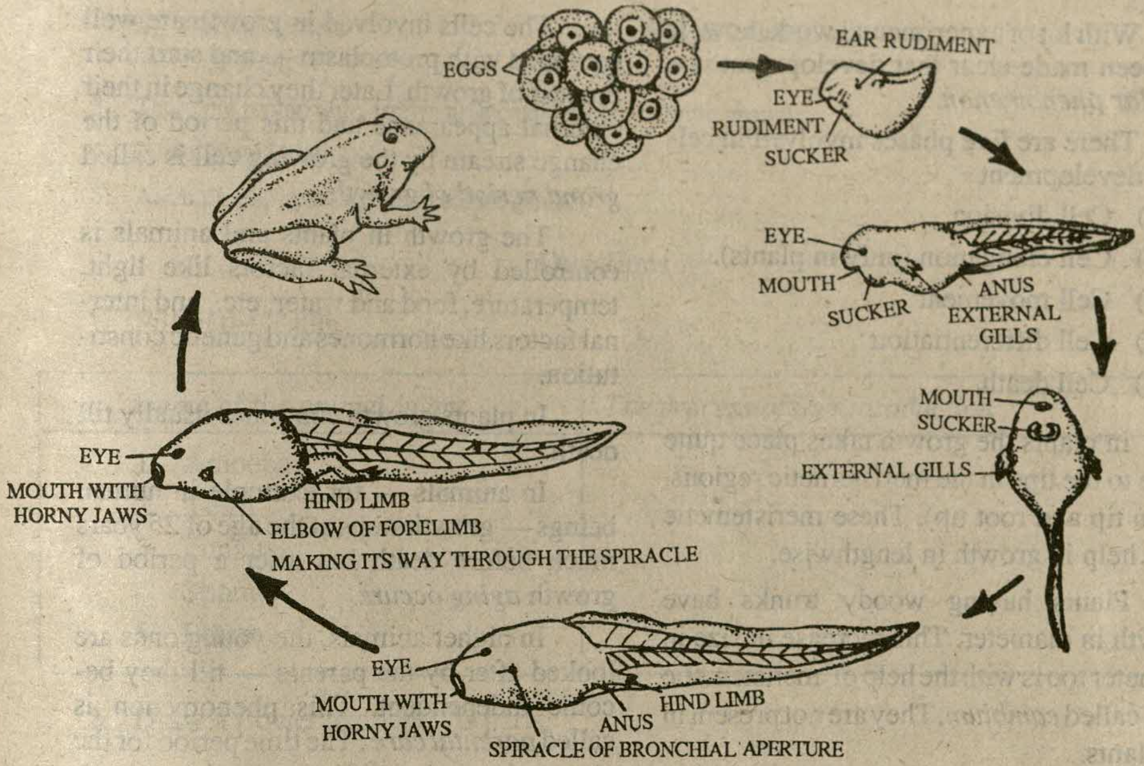


Fig 15.15 Life cycle of frog.

In Animals

The process of growth and development is very well developed in animals.

If we take an example of frog, we make the following observations :

(1) The male and female frogs lay sperms and eggs in the pond simultaneously.

(2) The eggs and sperms fuse together to form a *zygote*. This is called *fertilization.*

(3) The zygote undergoes an orderly cytoplasmic and nucleic division.

(4) Later, different kinds of embryos are formed one after another.

(5) The embryo now undergoes various changes and forms a *tadpole.*

A tadpole is called a *larva.*

A larval stage is comparable to embryonic stage which is independent of the mother or of the yolk for its nourishment.

(6) A tadpole undergoes various changes in itself.

(7) We can see from the diagram that a tadpole is very different from an adult frog.

Therefore, this tadpole undergoes various drastic changes to become an adult. This is called *metamorphosis.*

Metamorphosis is a process of changes in which a larva undergoes to become similar in its structure and function like its adult. The process is seen in butterfly too.

In human beings also, there are lots of embryonic developmental changes taking place before an infant is delivered. In animals, the growth is all over.

With lot of experimental work, now, it has been made clear that development is a *cellular phenomenon.*

There are five phases involved in cellular development :

(1) Cell division.
(2) Cell elongation (only in plants).
(3) Cell movement
(4) Cell differentiation
(5) Cell death.

In plants the growth takes place quite close to the tips in the meristemetic regions. (stem tip and root tip). These meristemetic cells help in growth in lengthwise.

Plants having woody trunks have growth in diameter. This increase in size in diameter too is with the help of meristemetic cells called *cambium.* They are not present in all plants.

The cells involved in growth are well-equipped with protoplasm — and start their process of growth. Later they change in their external appearance and this period of the change stream by the growing cell is called *grand period of growth.*

The growth in plants and animals is controlled by external factors like light, temperature, food and water, etc., and internal factors like hormones and genetic constitution.

In plants growth continues usually till death.

In animals — for example in human beings — growth stops at the age of 25 years much before death but after a period of growth *aging occurs*.

In higher animals, the young ones are looked after by the parents — till they become independent. This phenomenon is called *parental care* . The time period for the *parental care* varies from animal to animal.

Summary

Reproduction

1. All organisms reproduce, to maintain the continuity of its kind.
2. Reproduction may be
   (*i*) Asexual reproduction (*ii*) Sexual reproduction.
3. Organism reproducing from any body part or a cell into a new individual, it is said to *asexual reproduction* .
4. Plants too reproduce from their plant parts as leaf, root or stem. Such reproduction is *vegetative reproduction.*
5. Animals and plants reproduce, when the male cell (gamete) fuses with the female cell (egg or ovum). Such a process of reproduction is called *sexual* reproduction.
6. The process of sexual reproduction varies in different organisms.

Growth

1. All living organisms, unicellular or multicellular, grow in size.
2. There are five phases involved in cellular development :
   (*i*) Cell division (*ii*) Cell elongation

(*iii*) Cell movement (*iv*) Cell differentiation

(*v*) Cell death.

3. There are remarkable, irreversible changes occur during growth.
4. Plants grow indefinitely.
5. Animals stop growing much before death.

Questions

1. Fill in the Table

Name of the animal/plant	*The process of its reproduction*
1. Amoeba 2. Yeast 3. Fungus 4. Sponge 5. Potato	

2. Draw a flower and label its parts.
3. Define the following.
   (*i*) Asexual Reproduction. (*ii*) Sexual Reproduction.
   (*iii*) Regeneration. (*iv*) Vegetative Reproduction.
4. Draw a diagram of Amoeba underlying binary fission.
5. What parts of the flower give rise to the following :
   (*i*) Pollen grains. (*ii*) Male gamete
   (*iii*) Ovule (*iv*) Fruit
   (*v*) Seed.
6. What is the young one of a frog called ?
7. Where does the young one of the human develop ?

8. Name the organs of the humans which
   (*i*) Produce sperms in male (*ii*) Produce eggs in female.

9. In plants growth
   (*i*) in length is controlled by ....
   (*ii*) in diameter is controlled by ....

10. Explain clearly *metamorphoses.*

11. Define
    (*i*) Growth (*ii*) Development (*iii*) Fertilization.

12. Make a list of the factors that help in growth and development of organisms.

Activities

1. Do experiments showing germination with
   (*a*) moong seeds (*b*) grain seeds (*c*) Red Kidney Bean (Rajma) seeds

2. Collect the stages of life cycle of :
   (*i*) Butterfly (*ii*) Frog.

□ □

CHAPTER 16

FOOD

16.1 What have you observed from the pictures ?

Now immediately a question comes to your mind ; what about plants ?

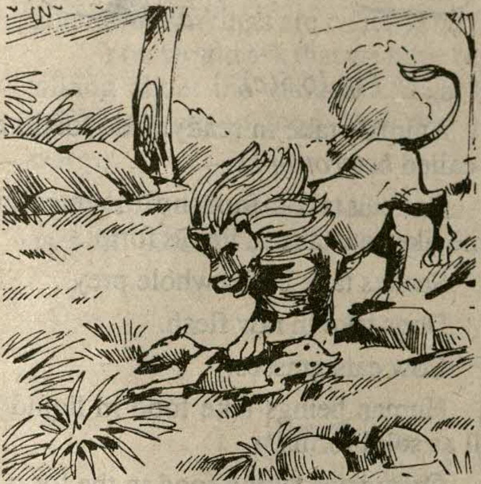


Fig 16.1. A lion ready to prey on a deer.

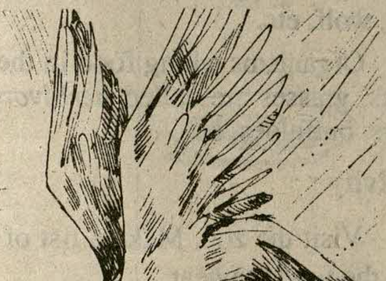


Fig 16.2. A hawk preying on a bird.

Do they eat food like animals ? If so, what type ? Otherwise what do they do ?

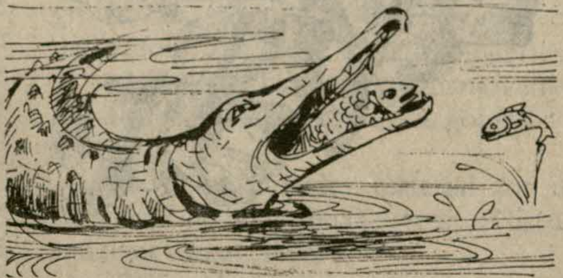
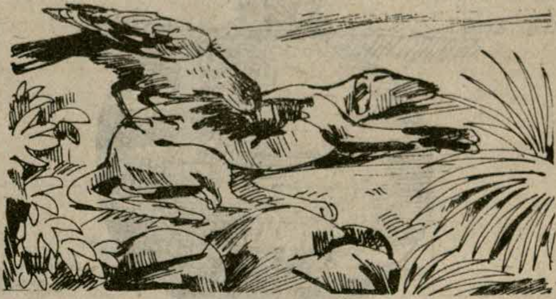


Fig 16.3. A crocodile capturing small fish.



A crow eating dead body of an animal Fig. 16.4.

The plants use stored food for themselves as food.

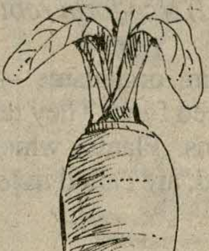


Fig.16.5(a) Fusiform root of radish.

Fig. 16.5(b).

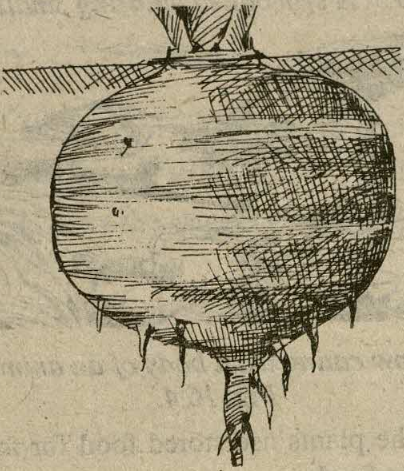


Fig. 16.5(d) Napiform root of turnip.

All living organisms — plants and animals — need food. They take in food in different forms. Plants, which synthesize their own food, are called *autotrophs*.

Fig.16.6(a) Cat licking milk.

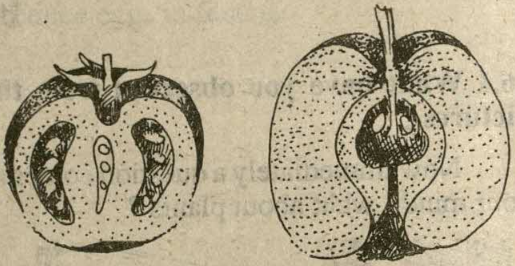


Fig.16.5(c).

Animals take in readymade food and are called *heterotrophs*.

Animals take in food in different forms. Some like cats take in liquid form.

Snakes take in the whole prey.

Dogs take in raw flesh.

Cow eats grasses.

Human beings take food in liquid as well as solid forms.

Organisms taking food in the form of flesh, meat etc., are called *carnivorous e.g.*, lion, wolf, etc.

Organisms taking food in the form of fruits, grasses are called *herbivorous e.g.*, cows, buffaloes, etc.

Activity :

Visit the zoo. Make a list of animals, and the food they eat.

Fig.16.6(b) Cow eating grass.

Organisms taking food which consists of meat and vegetables etc., are called *omnivorous, e.g.*, human beings.

In our society, there are many superstitious and wrong notions about the types of food that we should eat ; for example, if you eat a lot of ghee, you become more muscular and strong. If you eat almonds you become more sharp in your thinking etc. These unscientific thinkings are called *food fads*.

You would ask that we have been only talking about the variations regarding the different types of food. *Now, the question arises.*

16.2 Why do we eat food ? What are the uses of taking food ? Why can't we do without food ?

Food is a generalised term, which includes all the materials taken in through the mouth and are necessary for the activity, growth and well-being of body. We can divide food into the following categories :

1. Food provides *energy* for movement and all the chemical processes going on in the body.

2. Food provides material for the *growth* of the body and the repair of tissues and their damaged parts.

3. Food helps in the replacement of the worn out parts—may be in the form of skin etc. Mithous of our red blood cells break everyday.

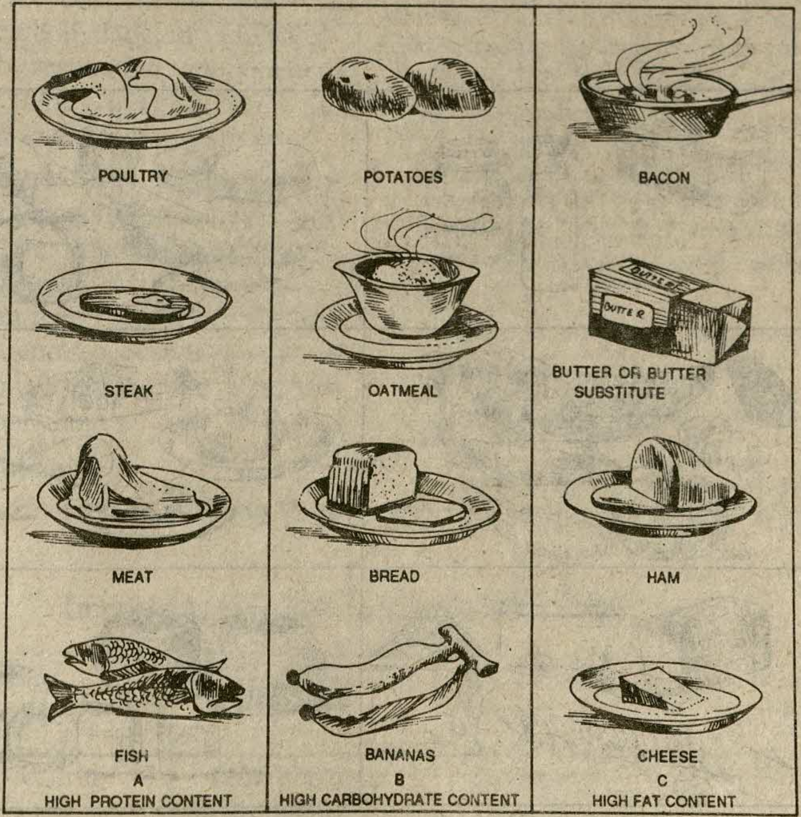


Fig. 16.7 Categories of food.

We use minimum energy, when we sleep. The energy is stored for us to utilise at the time of work.

Energy value can be measured in heat units, called *calories*.

A calorie is the amount of heat required to raise the temperature of 1000 c.c. of water by one degree centigrade.

The number of calories required in an average day's activity varies with the kind of activity and with the age.

Calories required :

For child under 2 yrs.	1,000 calories
For child from 2 to 5 yrs.	1,300 calories
For child from 6 to 9 yrs.	1,700 calories
For child from 10 to 12 yrs.	2,000 calories
For child from 12 to 14 yrs.	2,200 calories

16.3 Balanced Diet

For a good healthy body, we must take balanced diet. This diet varies from person to person, doing different work, in males and females, and in different age group children.

In human beings, these needs are met if the diet includes the following :

1. Carbohydrates
2. Proteins
3. Fats
4. Vitamins
5. Salts and Minerals
6. Water
7. Roughage or Fibre.

A good food must not only include all these categories but they should be in the right proportions for the person concerned. This is called *balanced diet.* A balanced diet

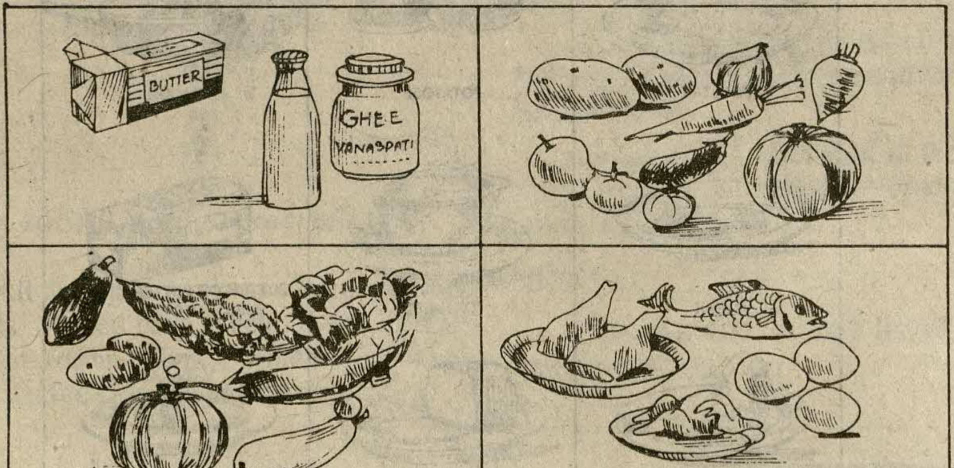


Fig. 16.8 Products having nutritious elements.

must contain enough carbohydrates and fats to meet our energy needs. It must contain enough proteins of the right kind to make new cells and tissues for growth and repair. The diet must also contain vitamins, mineral salts, plant fibres and water.

16.4 Functions of various Components of Food

Functions of Carbohydrates :

The major carbohydrates in man's diet are starch, sugar and direct plant material in the form of cellulose. Starch is abundant in potato, wheat, maize, rice and others. Sugar is mainly taken by us in the form of cane sugar (sucrose).

Carbohydrates are principally of value, as energy giving food. They are the cheapest and readily available in most of the food materials. They are, thus, the main source of energy. When carbohydrates are oxidized to provide energy by respiration they are broken to CO_2 and H_2O. *One gram of carbohydrate can provide 16 K joule of energy/approx.*

If we eat more carbohydrates than we need for our energy requirement, the excess is converted in the liver to either *glycogen* or *fat.* The glycogen is stored in liver or muscles. The fat is stored in liver or muscles. The fat is also stored in fat depots, near kidneys or under the skin. Our food should, therefore, not have too much of carbohydrates.

Functions of Proteins:

Examples of food containing high protein contents are meat, white of an egg, beans, pulses, cheese, milk, fish etc. Proteins help in providing growth material needed to build up cells and tissues. In other words, proteins help in growth of an individual.

Deficiency of proteins can prove to be fatal. Young children taking food linked with protein deficiency suffer from a disease called *Kwashiorkor.*

Fats and carbohydrates cannot replace proteins.

Symptoms : A child becomes irritable, shows skin cracks, liver gets damaged.

Functions of Fat :

Animal fats are found in meat, milk, cheese, butter, ghee, yolk of an egg. Plant fats occur as oil in fruits and seeds.

Fats are used to form most of cell structures like cell membrane. When oxidised during respiration, they give twice as much energy as carbohydrates of proteins.

Minerals and Salts: Minerals needed are: P, S, N_2, Cl_2, K, Zn, Fe, CO, Mg, Na, etc.

They are essential, because they provide many of the elements needed for growth, protection and the regulation of body activities.

Calcium. For (*i*) Strong bones, teeth.

(*ii*) muscle contraction.

Sodium + Potassium are needed by all cells.

Iron. For making red blood cells in blood. Deficiency of iron causes anaemia.

Important mineral elements needed in the body

Element	*Daily requirement*	*Use in the body*	*Deficiency Results in*	*Some good sources*
Iodine	0.1 mg	Forms hormone in the thyroid glands.	Goitre and reduced growth.	Sea fish, iodised table salt, cheese.

Iron	5-15 mg	Forms haemoglobin in red blood cells, which help in carrying oxygen.	Anaemia	Green vegetables, liver, yeast, egg yolk, kidney.
Phosphorus	1.0 g	Formation of bones and teeth. Needed in the nucleus and for energy release.	Rickets	Cheese, meat, fish, egg, nuts.
Calcium	0.7-2.0 g	Formation of bones and teeth, assists blood clotting.	Rickets	Milk,cheese, green vegetables.
Sodium	Traces	Blood plasma and keeps cells in proper order.	Rarely deficient.	Table salt, vegetables etc.
Potassium	Traces	Blood plasma and keeps cells in proper order.	Rarely deficient.	Vegetables etc.
Copper	Traces	Makes iron into haemoglobin.	Rarely deficient.	Liver, peas, beans, lentils.

Water. Water is an esential part of our diet and has many uses. It is so vital in maintenance of life that a person without water dies sooner than without food. Water takes part in the most important functions going on in the body. About two-thirds of the human body is made up of water. We lose water by evaporation, sweating, urinating and breathing. We have to make good this loss by taking in plenty of water with the diet.

Functions and Important Sources of Vitamins

Vitamins	***Best Sources***	***Essential For***	***Deficiency Symptoms***
Vitamin A	Fish liver oil; liver and kidney ; green and yellow vegetables, yellow fruit, tomatoes, butter, egg yolk.	Growth ; Health and eyes; Structure and functions of the cells of the skin and mucous membranes.	Retarded growth, Night blindness; Susceptibility to infections; Changes in skin and membrances; Defective tooth formation.
Vitamin B	Sea food, meat, soyabeans, milk,whole grain, green vegetables, fowl.	Growth;Carbohydrate metabolism; Functioning of the heart, nerves and muscles.	Loss of appetite and weight ; Nerve disorders ; Faulty digestion (*beri beri*).

Vitamin C	Citrus, milk,other fruits, tomatoes, leafy vegetables.	Teeth development ; Gum health	Sore gums
Vitamin D (oil soluble)	Leafy vegetables, fish liver oil, liver, fortified milk, eggs.	Growth ; Building and maintaining bones, teeth etc.	Soft bones
Vitamin K (Water Soluble)	Green vegetables, soyabean oil, tomatoes.	Normal clotting of the blood ; Normal liver functions.	Haemorrhages

Roughage :

Roughage also called *fibres* comprised mostly of plant cell walls, and occur in all vegetables, fruits and bread.

Fibres can not be digested by man.

Fibres increase the bulk in the large intestines, and help to retain water. This softens the faecal matter and helps in easy and quick egestion of faces.

A diet that does not contain the right proportion of these above mentioned components, makes an individual suffer. The individual is then said to suffer from *malnutrition.*

Milk is the only article of diet during the first weeks or months of a mammals life. It is an almost ideal diet since it contains proteins, fats, carbohydrates, mineral salts, particularly calcium and magnesiums and vitamins. For adults, it is not a wholesome diet, because of varied needs of the adults.

Food Tests : *To find the type of food.*

(*a*) **Starch** : A little starch powder is shaken in a test tube with some cold water, and the boil to make a clear solution.

When the solution is cold, add 3 to 4 drops of iodine solution. You get *blue black* colour. This is a test for confirming starch.

(*b*) **Glucose :** A little glucose is heated with Benedict's solution in a test tube. The solution changes from clear blue to green, yellow and then red precipitate.

(*c*) **Fat :** Put a drop of any kind of fat (ghee or oil) on a piece of paper. It leaves a transluscent man.

(*d*) **Protein :** Take 1% solution of white of egg, add 5 cc of sodium hydroxide, followed by adding 5 cc of 1% copper sulphate solution. A purple colour indicates the presence of protein.

Food tests can be used as sample of food to find out what food materials are present.

Summary

1. All living organisms require food.
2. Food helps in building up body.
3. There are different components of food.
4. Carbohydrates and fats provide energy.
5. Proteins help in growth and repairing wounded parts of the body. Vitamins are very essential for healthy body.
6. Minerals, water, roughage also are necessary components of food.

7. Milk is a satisfactory and ideal food.
8. Different age groups of human beings require different amount of calories.
9. We must make sure that our diet is balanced.
10. Food tests can be used to test samples of food.

Questions

1. Give the (*a*) souces and (*b*) functions of following foods :

Food *Source* *Function*

(i) Carbohydrate (ii) Proteins (iii) Fats
(iv) Vitamins (*a*) Vitamin A (*b*) Vitamin B (*c*) Vitamin C (*d*) Vitamin D (*e*) Vitamin K
(v) Minerals— (*a*) Calcium (*b*) Iron

2. Answer the following questions :
   (*i*) What is a balanced diet ?
   (*ii*) What are heterotrophs ?
   (*iii*) What are food ?
   (*iv*) What are the important minerals required by the body ?
   (*v*) Why should food contains enough of water ?
   (*vi*) Why is milk an ideal food ?
   (*vii*) What is the unit of heat ?
   (*viii*) In what form is extra carbohydrate utilized in your body ?
3. How would you test for the presence of fat, carbohydrates and proteins in your food ?

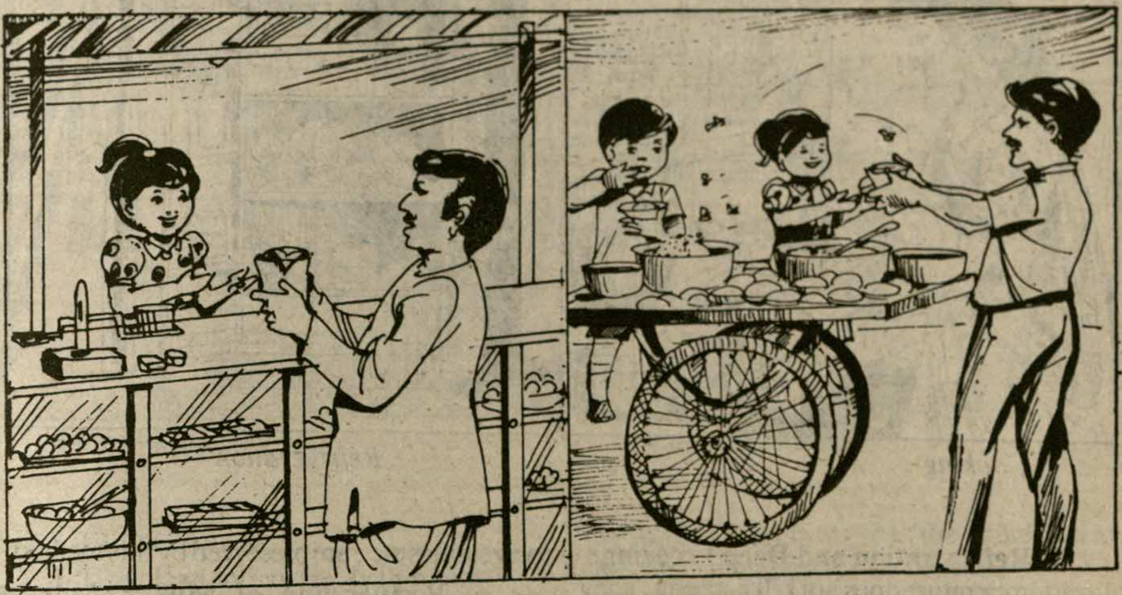
Activities

1. Make a list of your one week's diet, and find out, whether, it was a balanced diet you had or a diet causing malnutrition.

2. Make charts on :
   (*i*) Vitamins (*ii*) Common minerals.

CHAPTER 17

HEALTH AND DISEASES



Clean and covered food. *Eating uncovered food causes diseases.*

Fig. 17.1

Good health is something that many of us take for granted. It is much more important than an absence of disease. Good health involves all the organs of the body working properly. The following are some of the steps which we can take to make in the state of a good health.

17.1 Clean food and water

Fruits, vegetables which are eaten without cooking should be washed with clean water. Unless you have a supply of water which you know is clean and free from germs (bacteria) it is a sensible precautions to boil water to be used for drinking.

17.2 Preservation of food

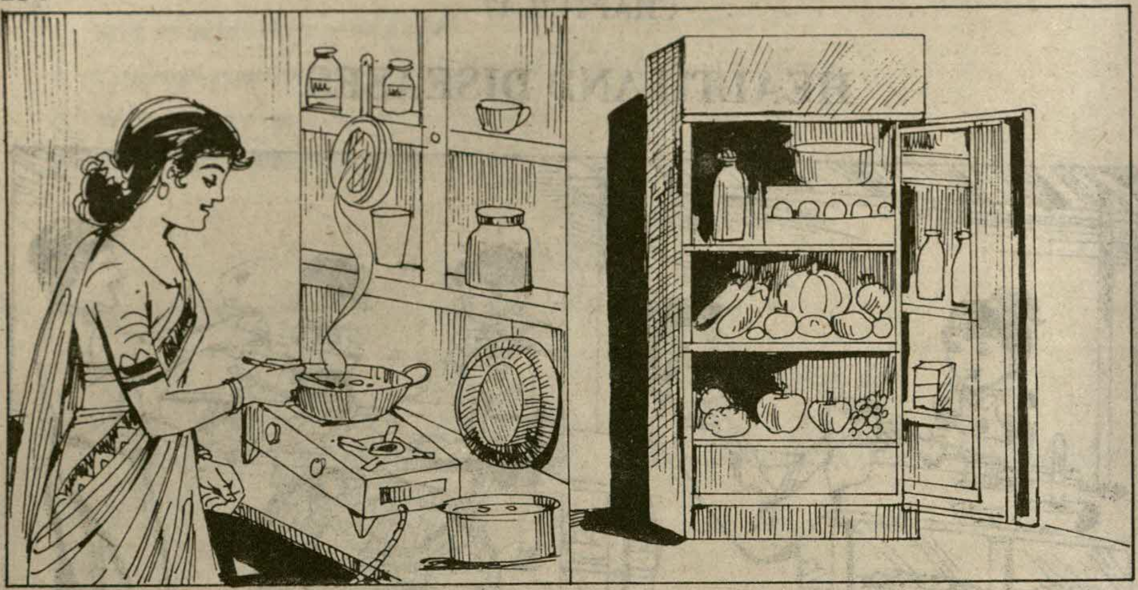
Now, you see that our health totally depends on food. So, we must preserve our food properly and should eat safe food. We should also protect our food. We know, if our food is kept uncovered, it gets spoilt. Germs of the diseases infect our food and cause diseases to us, when we eat the food.

You must have noticed that food in summer gets spoilt. Who spoils this food ?

Bacteria spoils our food — makes the food to stink and makes it poisonous. There are many ways of keeping our food safe, so that after eating that safe food, we do not fall sick.

Different Methods of Preserving and Keeping Food Safe.

1. Cooking : The spread of bacteria can be prevented by cooking food before it. Frying, roasting, baking, boiling etc., will kill bacterial germs present in the food.



Cooking

Refrigeration

Fig 17.2

2. Refrigeration and Deep Freezing : Low temperature does not kill bacteria. They become inactive in low temperature. Therefore, food can be stored in the referigerator or deep freezer.

3. Adding Vinegar, Sugar or Salt to Some Food : Excessive vinegar, sugar, or salt, if are added to the food are also the methods of preserving. The food, thus, can be preserved for some time and would remain safe.

Jam is very sweet. Extra sugar does not allow bacteria to multiply.

You pickle in vinegar, and put extra salt, this will, again, prevent growth of bacteria.

4. Drying : Some vegetables are preserved by drying. Loss of water does not allow bacteria to multiply and, thus, efficient method of preserving the food safe.

5. Canning : This is a very useful method of preserving and keeping food safe. Canning preserves the vitamins. Fruits, juices, vegetables etc., are preserved by this method.

6. Pastuerizing of Milk : Milk is preserved and kept safe by this method. The milk you get in packets is pastuerized milk and is safe to drink.

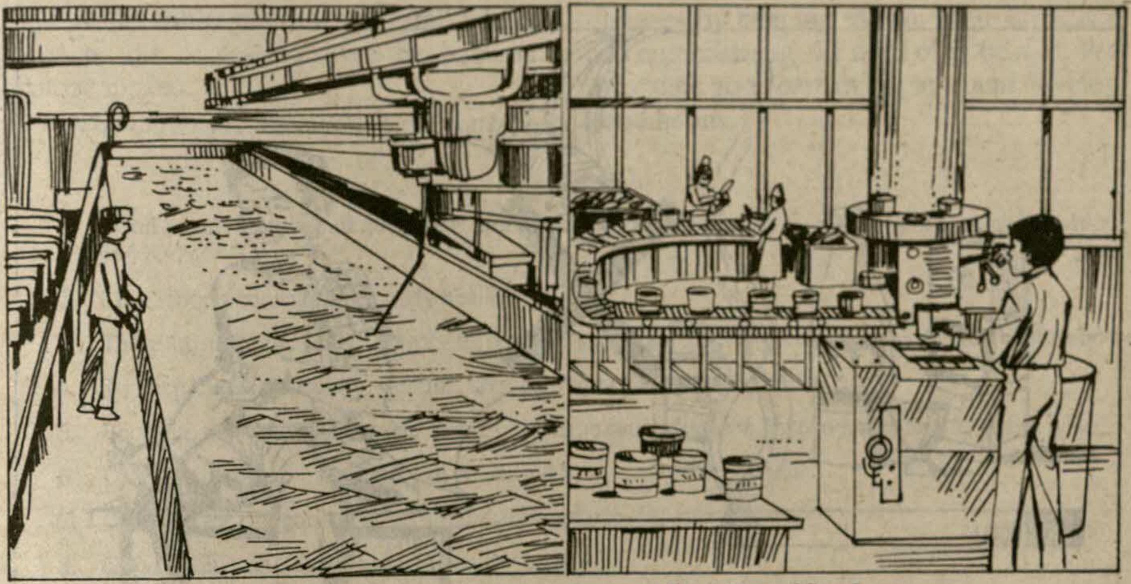
Balanced diet, nutritious food and food free from bacterial germs are not the only ways to remain healthy. Healthy body depends more on hygiene, sanitation and healthy habits of people.

17.3 Hygiene :

Proper care should be taken to keep surroundings and inner side of the house clean. Caution should be taken that kitchens and bathrooms are clean. One must look after the personal hygiene in order to have the less chances of falling sick.

Personal hygiene :

1. Wash your hands after and before eating food.
2. Wash your body and hairs regularly.
3. Wear clean clothes.



A Cheese-making plant. *Canning of food*

Fig. 17.3

4. Cut your nails.
5. Use clean toilets and bath rooms.

17.4 Sanitation — Sewage disposal

Human faeces and urine coupled with household waste water and rain water make up *sewage*. There should always be a proper way of disposal of sewage ; or, there is need for good sanitation to remove the sewage safely through pipes. If hygiene and sanitation are not taken care of, there are fully chances of the spread and multiplication of bacteria mosquitoes and other micro-organisms to cause harm to the human body. Poor hygiene and sanitation would expose the bacteria mosquitoes and micro-organisms to come in contact with flies. The flies will carry the infection to the food to be eaten by man. Such food is called *contaminated food*.

Poor hygiene can, also, infect the food and the drinking water.

Let us learn about the diseases which can be caused due to poor hygiene and sanitation. Because, it exposes the bacteria and disease causing germs to the man.

17.5 Diseases

Disease is the result of a change from the normal health.

Diseases are not only caused by micro-organisms. But, there are many ways, by which, health can be deteriorated. We have talked about diseases caused by malnutrition. We know many people misuse their body and make the body suffer. Do you know, how ? It is by smoking, taking drugs and alcohol. All these harm the healthy body.

Now, we shall talk about some other diseases, we suffer from. Needless to mention, the diseases are caused by harmful organisms.

The diseases caused by micro-organisms may reach us through air, water, food or by direct contact. In other words, diseases caused by viruses, bacteria, protozoa, fungi, worms and transmitted from person to per-

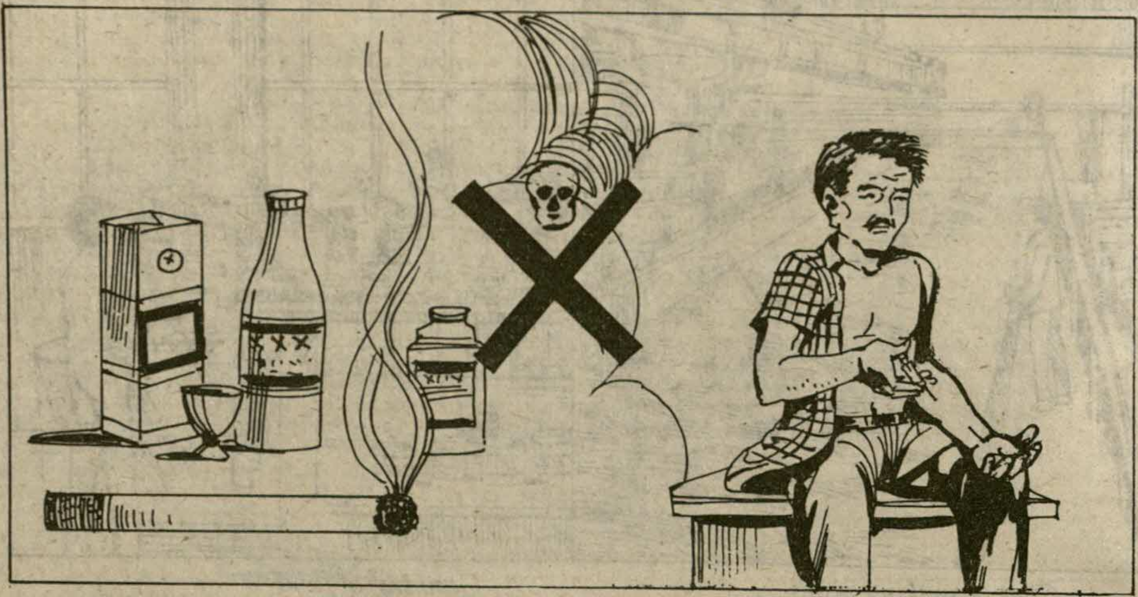


Fig. 17.4 Taking drugs and alcoholic drinks causes severe harm to the body

son are called *infectious* or *communicable diseases*. On the other hand, the diseases caused by deficiency or abnormal function of any organ are *non-communicable* diseases. These diseases affect only the individual and remain restricted to the person suffering from disease. We have discussed the deficiency diseases caused by lack of minerals and vitamins. We have talked about the disease caused by lack of protein too.

Table: Some Common Diseases

Disease	*Causative agent*	*Caused through*	*Symptoms*
1. Tuberculosis (T.B.)	Bacteria	Respiration	Cough, loss of strength, weakness, paleness
2. Typhoid	Bacteria	Contaminated food & water	Fever, weakness, Constipation , diarrhoea
3. Tetanus	Bacteria	Infected soil or rusted iron	pain, muscles contract, fever
4. Influenza	Virus	Respiratory system	General weakness, headache, pain, high fever with shivering
5. Measles	Virus	Nose	High fever, skin eruptions inflammation of membrane of nose
6. Malaria	Protozoa	Bite of mosquito	Restlessness, fever, headache, cold, shivering
7. Amoebic Dysentery	Protozoa	Contaminated food or water	Severe diarrhoea, weakness, digestion becomes weak.

In the table given here we talk about some of the diseases caused by bacteria protozoans etc.

The care must be taken to prevent the diseases by keeping the environment clean and emphasizing the need of good diet. We must take good care of hygiene and develop good habits.

Summary

1. Good health involves all the organs of the body working properly. It involves feeling well in mind and body.
2. Clean food and water keep body healthy.
3. There are different ways of preserving food, milk and keeping it hygienic for maintaining healthy body.
4. To keep the body healthy, we must take care of hygiene and sanitation.
5. Bacteria, mosquitoes and other micro-organisms cause diseases, by contaminating food and water.
6. Diseases by micro-organisms can be caused by air or by direct contact.
7. Diseases are categorised as communicable and non-communicable.
8. Good habits can help in keeping healthy body.

Questions

1. Answer the following questions :

(*i*) What is malnutrition ? (*ii*) How does your food get contaminated ?

(*iii*) What are communicable diseases ?

(*iv*) What are non-communicable diseases ?

(*v*) How would you prevent malaria from spreading ?

(*vi*) What is sanitation ? (*vii*) What is sewage ? (*viii*) What is infection ?

2. Name the diseases caused by :

(*a*) bite of mosquito.......................... (*b*) bacteria.....................................

(*c*) virus... (*d*) deficiency of Vitamin A ....

(*e*) contaminated food & water .... (*f*) contaminated milk.......................

3. Write the symptoms of :

1. Tetanus 2. T.B. 3. Measles 4. Influenza 5. Malaria

4. Make a list of ways, you can keep yourself and people around you healthy.

Activities

1. Make charts on :

1. Common diseases and their control measures (Prevention).

2. Make a chart for your classroom, giving all the good habits which will help you to maintain the hygiene.

(*i*) In the class room, (*ii*) In the school, (*iii*) At home.

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CHAPTER 18

SOILS

Introduction

Most of the surface of the earth is covered with water. If you look at the globe, you will find that $\frac{3}{4}$th of the earth is nearly under water. The land surface of the earth is covered with soil.

18.1 How Soil is Formed ?

The solid part of the earth is made up of rock. Slowly, some of this rock is changed into soil. It is in this soil, which contains animals and sustains plant life.

On hot sunny days, the surface of the earth becomes very hot. The outer surface expands due to the heat, while, the inner part of the earth remains cool. The outer expanded surface pulls away from the inner cooler surface and, thus, splitting occurs. This process of expanding and splitting continues for many years. The rock slowly becomes soil.

Rain water when gets into the cracks of the rocks, it might freeze during winters. Similarly, it can be the ice, which might split the rock and, thus, form soil.

Don't you think, the roots of plants, when make their way down the earth, can break rock, and help in forming soil.

Some kinds of *acids* also assist in changing rocks into soil.

Strong winds and running water too break the rocks and aid in forming soil.

The soil, thus, formed may be of many colours. It may be black, brown, yellow or grey.

The colour of the soil indicates us the type of minerals it contains.

Red and yellow coloured soils are because of the iron salts present in them.

Black soils are the richest soil. They are rich in humus and in calcium.

The soils of different places have different colour, texture and water content.

Types of soil :

1. **Red Soil :** The soil is found in those parts of the country where attitude, *low, high temperature* and seasonally wet conditions are present, like in parts of Orissa, Andhra Pradesh, interior regions of Kerala and Tamil Nadu.

Red soil suffers due to calcium deficiency and has little humus content. They have red colour because of ? You know that.

2. **Black Soil :** One of the richest soils. They are rich in humus and in calcium. They are fertile soils requiring little fertilizers. The soil covers large areas in Gujarat, Madhya Pradesh, Maharashtra etc.

3. **Alluvial Soil** : The soil carried from their parent rock by river over long distance is alluvial soil. It is fertile and contains sand, clay and gravel. The soil covering Uttar Pradesh, Haryana, Bihar and Bengal is alluvial.

4. **Desert Soil** : It is grey in colour in temperate regions and red in tropical regions. It does not contain any humus. It is a sandy and porous soil. The soil can be cultivated well if irrigation water is available. Parts of Gujarat, Rajasthan have desert soil.

5. **Mountain Soil :** This soil is found in the Himalayan region and North–Eastern parts of our country. The soil is very fertile as they have the highest humus contents.

6. **Laterite Soil :** The soil of the rainy climate is called laterite type.

Activity :

Collect some samples of different colours of soil.

The colour of the soil depends upon the kinds of rock material or minerals, the soil contains.

18.2 Composition of Soil

Shake a little bit of garden soil in a test tube full of water.

Allow the soil to settle, without disturbing the same for some time.

This is called *sedimentation* test.

This helps in separating different components of the soil.

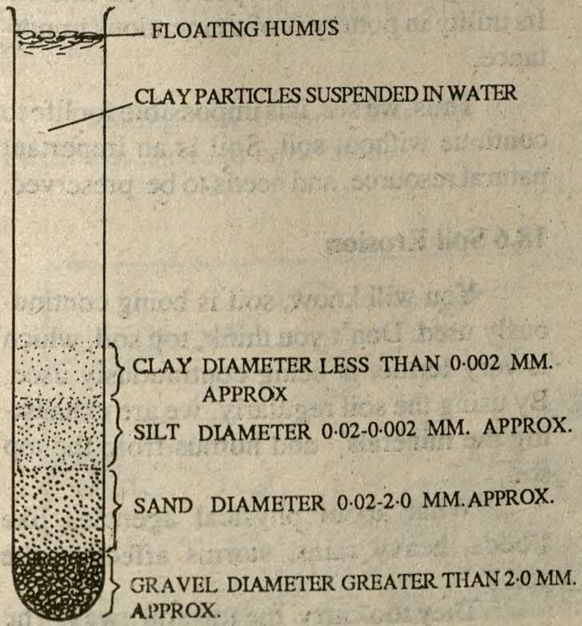

FLOATING HUMUS
CLAY PARTICLES SUSPENDED IN WATER
CLAY DIAMETER LESS THAN 0·002 MM. APPROX
SILT DIAMETER 0·02-0·002 MM. APPROX.
SAND DIAMETER 0·02-2·0 MM. APPROX.
GRAVEL DIAMETER GREATER THAN 2·0 MM. APPROX.

Fig. 18.1 Result of Sedimentation Test.

The soil is, mainly, composed of :

1. **Humus :** It is the black material that floats to the top of the tube. Humus is the dead and decayed remains of plants and animals. It is, thus, formed by the saprophytic activity of fungi and bacteria. The presence of humus in the soil is very essential for healthy growth of plants.

2. **Minerals** : The soil may have very fine mineral grains— the *clay particles*. It may have bigger particles— the *sand particle*; or, still bigger particles— the *gravel particles* (See Fig. 18.1) . A type of soil may be clay or sandy, depending upon the size of mineral particles. These particles settle in the tube depending upon their size.

3. **Air** : Soils do contain air. This is, again, essential as it allows the plants and animals to breathe.

4. **Water** : It is a remarkable component of soil. All minerals present in the soil are absorbed by plants in a solution form only.

5. **Living Organism :** Many types of organisms (living) live in the soil. They may be microscopic or big animals, for example, bacteria, fungi, insects, worms etc.

18.3 Loam is the Best Soil

Loams are the most fertile of all soils. They possess all good characteristics, which help in healthy growth of plants :

The best loam has

50% of sand

30% of clay

20% of humus.

This type of soil has plenty of air for the roots of the plants to breathe.

Holds enough of water for dissolving minerals and forms absorbing source to plant roots.

Sandy soil, on the other hand, does not hold water at all.

18.4. Layers of Soil

Activity:

If you dig little bit of earth in your school you will observe different layers. The upper one is the top dark layer of soil. It has humus and enough of minerals. This layer is called the *top soil* (Horizon A). This is supposed to be the fertile soil layer for the growth of plants. Under the top soil, there is a lighter layer. This soil layer has enough of minerals and is called *subsoil* (Horizon B).

Beneath the layer of subsoil, there are layers of weathered rocks and pebbles (Horizon C). (Fig. 18.2).

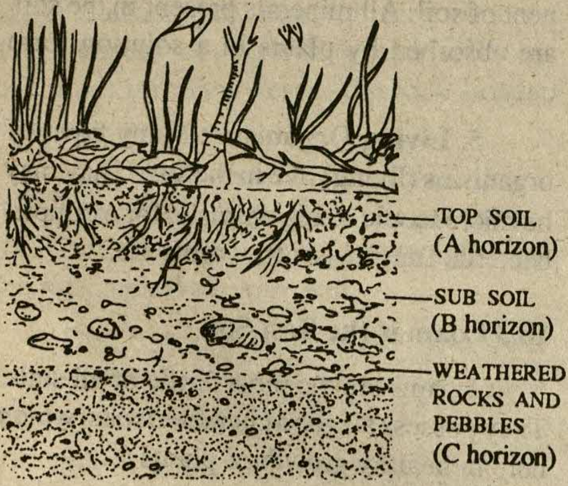


Fig. 18.2 Layers of Soil

18.5 Soil as a Natural Source

Plant roots take water and minerals from the soil.

Soil is a habitat for soil organism; earthworm, rats, ants, mites, insects etc., and thousands of micro organisms (Fig. 18.3) live beneath the soil.

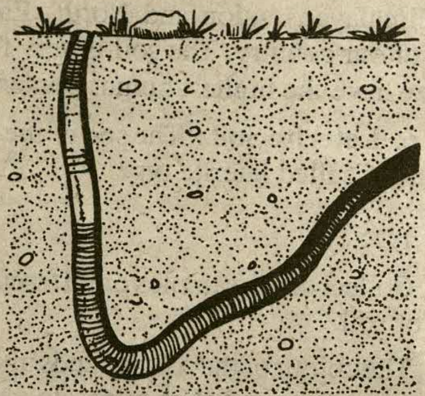


Fig. 18.3 An earthworm burrowing through soil

It is the soil that supports life on the land.

Soil is the chief source for the supply of minerals to all living organisms, directly or indirectly.

The soil's utility in construction of buildings of different types is well-known. Its utility in pottery is of tremendous importance.

Thus, we see, it is impossible for life to continue without soil. Soil is an important natural resource, and needs to be preserved.

18.6 Soil Erosion

You will know, soil is being continuously used. Don't you think, top soil, which is very fertile, is being continuously used. By using the soil regularly, we are exhausting the minerals and humus from the top soil.

What about physical agencies like floods, heavy rains, storms affecting the soil ?

They too carry the top soil away. The soil becomes less fertile and less useful, when the top soil is washed off. This loss of top soil is called *erosion*.

Cutting of forests also brings about erosion by exposing the top soil. Graziers also make the soil less fertile by reducing the soil cover.

18.7 Soil Conservation

Word *conservation* means wisest use of natural resources so that they are useful for maximum number of people for a longer period of time.

Soil being an important natural resource should be conserved. What layer of the soil must be conserved ?

It is the top soil.

This conserving the top soil is called *soil conservation*.

Planting new grass on bare soil that once was covered with grass is called *regrassing*.

Planting new trees on land that once was forest is called *reforestation*.

Regrassing and reforestation are important factors of soil conservation. It must be kept in mind, cutting down of forest and plants should be completely stopped.

Before planting the crops, the farmer loosens and breaks up the soil, with a *plough*. The plough makes small ditches called *furrows*. If furrows are not made correctly, the farmer may lose valuable top soil (Fig. 18.4).

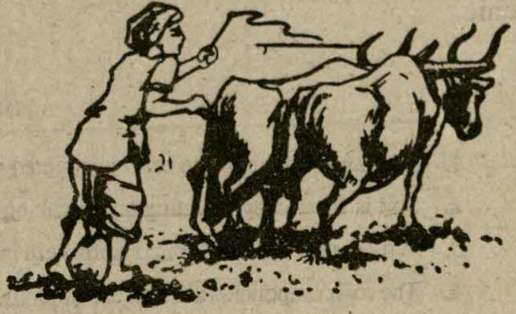


Fig. 18.4 Ploughing.

Soil can be conserved on the hills, by making steps called *terracing*. This helps in conserving the top soil. (Fig. 18.5).

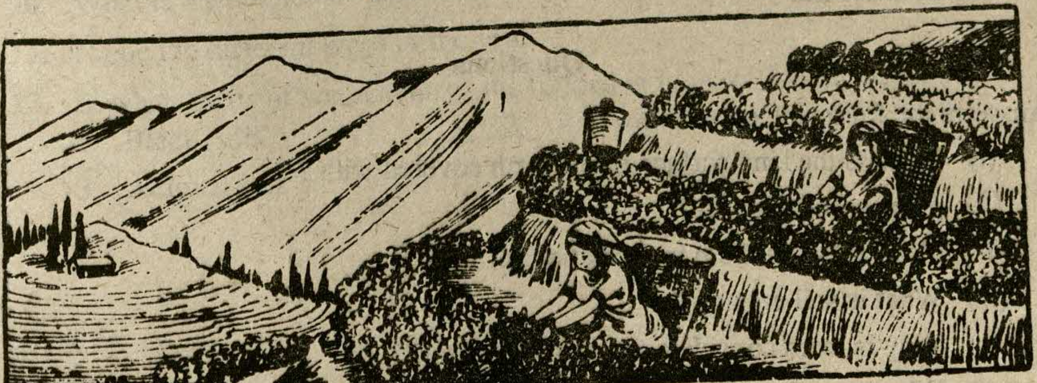


Fig. 18.5 Terrace Farming

Top soil should never be left uncovered. It would always be desirable that plants should be grown. This helps in conservation of soil.

The top soil can be conserved by adding good chemical fertilizers. Different plants require different doses of fertilizers, depending upon the kind of crop to be cultivated and caution has to be exercised in this matter.

18.8 Soil Pollution

The soil where animals live and crops are cultivated should always be kept hygienic.

Any susbstance that reduces the fertility of soil is called a *soil pollution.*

Defaecation in the open, on the fields contaminate the field and water.

With the advancement in the industry, and lots of industry coming up, the soil is being polluted with the industry and the factory wastes.

Good crop depends on good soil?

Don't you think indirectly good health too depends on good soil.

Summary

1. The land surface of the earth is covered with soil.
2. Soil is formed by splitting and breaking of the rocks.
3. Winds, rain water, heat and acids help in breaking of rocks.
4. The soil components are humus, minerals, air, water and micro-organisms and other living organisms.
5. There are different types of soils, but loam is the best soil for healthy growth of plants.
6. There are different layers of the soils— Top Soil, Sub-soil and Rocky layer.
7. Top soil is the best soil, and it needs to be conserved by methods of reforestation, regrassing, ploughing, terracing and adding fertilizers.
8. Cutting of trees, heavy floods, rains, winds, grazing expose the top soil to be carried away. The loss of top soil is called *soil erosion.*
9. Defaecation in the open fields, and industrial wastes on the fields pollute the soil. This is harmful for the life on the soil.

Questions

1. Answers the following questions :

(*i*) What is the land surface of the earth covered with ?

(*ii*) How is soil formed ?

(*iii*) How does heat help in formation of soil ?

(*iv*) What is soil erosion ?

(*v*) Why is loam considered to be the best soil ?

(*vi*) Why is sandy soil not very good for the healthy growth of plants ?

(*vii*) Why do we need to conserve soil ?

(*viii*) What is the most useful layer of the soil and why ?

(*ix*) What are regrassing and reforestation ?

(*x*) What is soil pollution ?

2. Complete the table :

S. No.	*Name of soil organisms*	*Name of compo-nents of soil*	*Name of some useful fertilizers*
1.			
2.			
3.			
4.			
5.			

3. Do the experiments of sedimentation test in the class. Write the observation by drawing diagram.

4. Name the different layers of the earth.

5. Write in detail, how top soil can by conserved ?

6. Make a list of ways which help in the formation of soil from rocks.

7. What is humus ?

8. Name the different types of soil.

9. Can the spray of chemicals, to kill weeds, to inhibit the growth of disease, to kill insect-pests on the plants, affect the soil pollution ?

10. What is the colour of the soil due to ?

11. Name the different types of the soil.

12. In what parts of your country, the following types of soil are found :

1. Black soil
2. Red soil
3. Alluvial soil
4. Desert soil.

Activities

Activity 1 : How well do different kinds of soil hold rain water ?

Things needed

(*a*) Clay soil

(*b*) Sandy soil

(*c*) Clay soil + sandy soil + humus.

(*d*) 3 small empty flower pots with a hole at the bottom.

(*e*) A bucket full of water and mug.

Fill in the three pots as follows :

Pot with clay soil ... A
Pot with sandy soil ... B
Pot with the mixture of sandy, clay and humus ... C

Now, pour enough of water in each of the pots containing different types or soil. Write your observations.

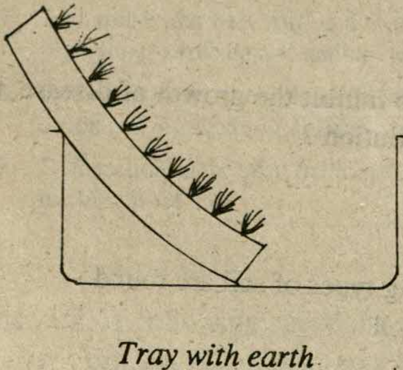
Activity 2 : Demonstration of Erosion

Take two plastic trays.

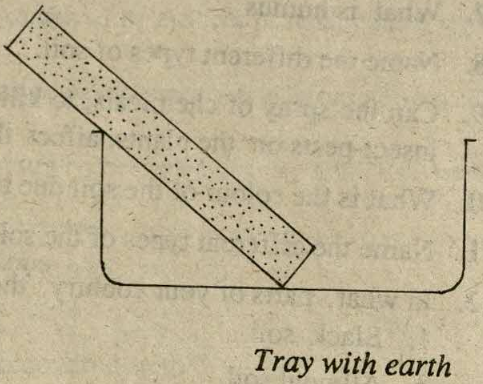
Put in *one*, enough of soil, and settle the soil well, by soaking it with water.

Put in the *other*, a piece of earth layered with green grass, large enough to fit in the tray.

Place the trays at an angle, as shown, in big troughs :



Tray with earth having grass



Tray with earth soil only

Now pour water in each tray.

What do you observe ?

Activity 3 : Find out what type of soil do you have in your town, city or state

CHAPTER 19

AGRICULTURAL PRACTICES AND IMPLEMENTS

19.1 Management of Plants and Animals is Useful to Man

We all are dependent on plants for various purposes, and in the same way on animals too. They are used partly as food and partly for many other purposes in our day-to-day life.

Activity :

Make a list of the uses of animals and plants to us.

We are directly concerned with *cultivated plants* and shall like to cultivate them under optimum conditions. So that, they give us better yield and good quality of food. In the same way, the animals, we are dependent on, are looked after and managed by us in such a manner that they function efficiently for us.

This all can be achieved, if good care is taken for the animals and the plants which provide us lots of materials.

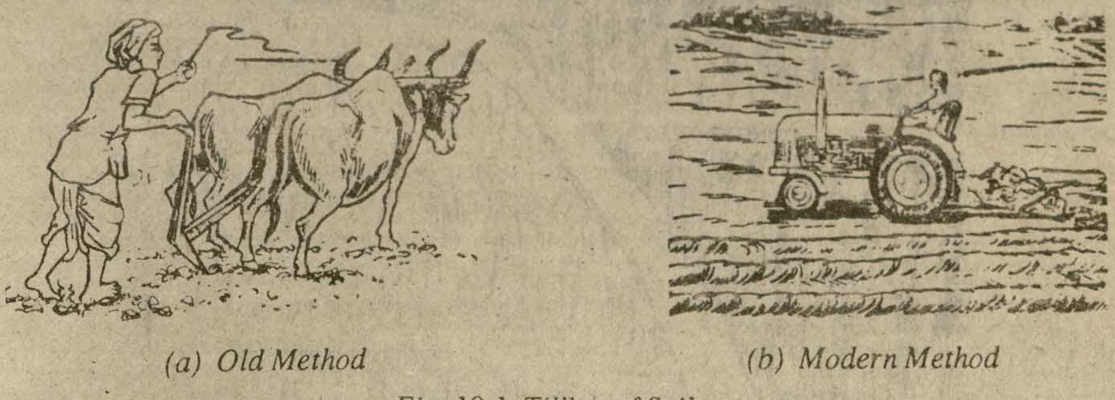
There are animals and plants managing on their own with the existing nature. Those are the ones in the forests, jungles, oceans, rivers etc. We shall be discussing in this lesson, how to grow and improve the plants we are dependent on. Similarly, what care should be taken of the animals useful to us.

19.2 Agricultural Practices and Implements

The yield of a crop can be increased by following a number of improved practices from sowing to harvesting. Implements required at the various stages of the crop production should be good and effective. You will learn about the various agricultural practices one by one in the following pages.

Soil Improvement

In order to get a better yield of crops, the soil under cultivation needs constant improvement. These improvements can be *physical*, for improving the physical nature of the soil ; *chemical* for improving the chemical contents, *i.e.*, the mineral contents in its correct proportions in the soil ; and



(a) Old Method *(b) Modern Method*

Fig. 19.1. Tilling of Soil.

biological to increase the living organisms, that are useful for plants, such as the nitrogen fixing bacteria. It also helps to destroy the harmful ones such as weeds, insects and pests that live in the soil and damage the plants.

Soil can be improved in many ways, but these following three methods are considered important :

1. **Tilling.** It includes ploughing and furrowing. This process ensures better aeration of the soil. It increases its water retention properties. Besides these, tilling also exposes the harmful insects living in the soil and finally, these are carried away by the birds.

2. **Liming.** Addition of lime improves the physical and chemical properties of the soil. Lime helps in the sticking of smaller soil particles, making them to larger particles. This process improves texture of clay soils. Chemically, it corrects the acidity of the soil.

3. **Manuring.** In order to increase the yield of crops, the soil must maintain its fertility. The fertility is lost if crops are grown continually in patch of land. This is due to the fact that the plants are continuously removing the minerals etc., from the soil. In order to replenish the soil, organic manure, obtained from green plants or mineral fertilizers produced artificially, are added to the soil.

Organic manures increase the humus content of the soil, thereby improving its physical and chemical properties.

Artificial or mineral fertilizers supply the much needed *nitrogen, potassium, phosphorus* and other minerals to the soil. The nitrogen content of the soil can be improved by the addition of fertilizers like ammonium sulphate. Super phosphate is the standard phosphate fertilizer. Sulphates and chlorides of potassium are the potassic fertilizers.

Soil fertility can also be conserved by *crop rotation*. In this practice different crops are grown in a definite sequence during the successive seasons. Growing of the same

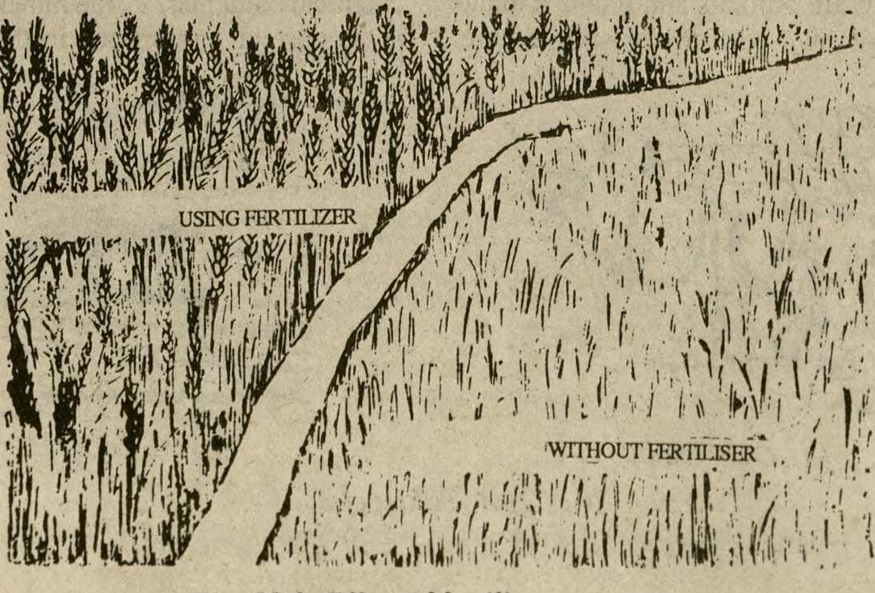


Fig. 19.2 Effect of fertilizer on crops.

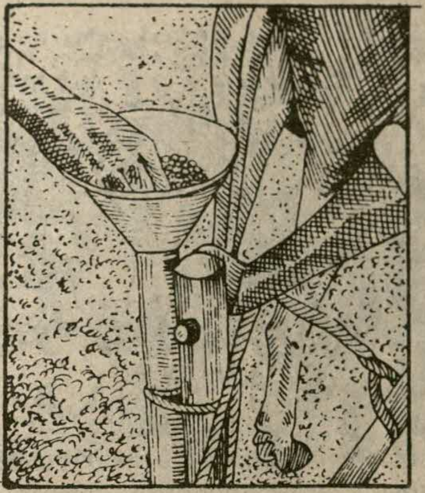


Fig 19.3. Seed Drilling

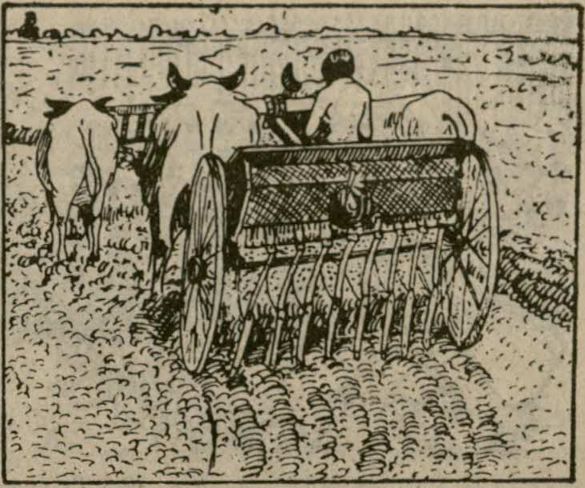


Fig 19.4. Ploughing

kind of crop on the same land continuously makes the land lose all its fertility. A good crop-rotation must include a root crop, followed by a cereal crop and a leguminous crop.

Different crops have different extent of penetration of their root systems. So choosing the right types of crops in crop rotation ensures that the soil is not exhausted of any particular mineral nutrient. Inclusion of the leguminous crop increases the nitrogen content of the soil, which will be needed very much by the succeeding crop.

Insect-pests which may be associated with a particular type of crop can also be wiped out by crop rotation.

Sowing

Before sowing, the seeds are treated with chemicals (fungicides) like Agrosan and Ceresan. This treatment also protects the seedlings from the attack of many diseases. Sowing of seeds is done through hand or by using seed drills. Usually a long iron pipe having a funnel at the top is fixed at the top back of the plough. Seeds put in the funnel reach the soil furrows made by the plough.

The seed bed is properly ploughed and prepared so that it should be soft and loose enough to permit the growth of the root. The levelling of seed bed is essential in order to ensure uniform distribution of irrigation water.

Care of Seedlings

Frequent and right irrigation is essential in the nursery, as the plants at this stage are more likely to dry up than the adult plants. The reason is that the soil is pre-enriched by applying manure. It is also necessary to remove the weeds as they compete with the crop for nutrients and sunlight. Chemicals like Parathion, Sevin, Dimercron, Thiodn and Rogar should be sprayed to protect the seedlings from the attack of diseases and pests.

Transplanting

Transplanting is the practice of planting the seedlings from the nursery to the main field. Transplanting is a common practice in rice and many vegetables. This is practised sometimes in wheat also.

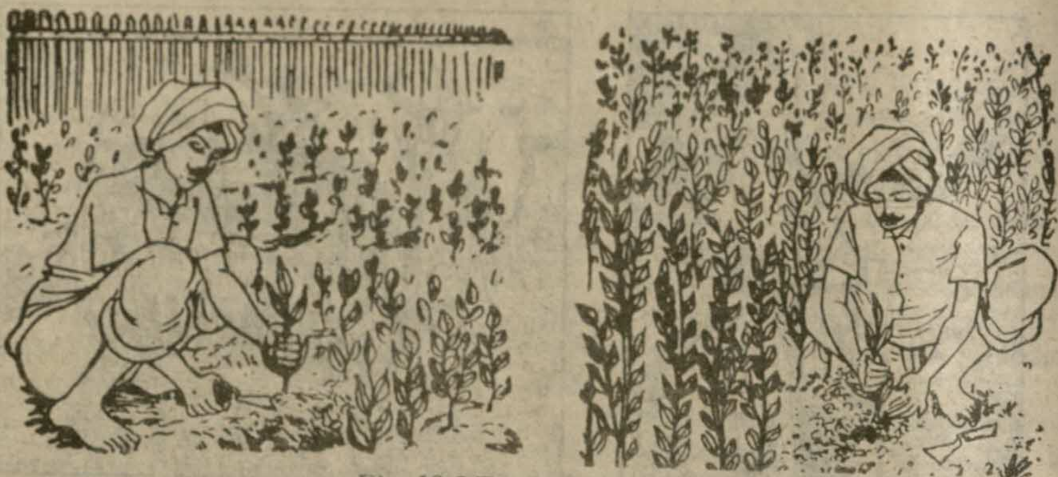


Fig. 19.5 Transplanting

Transplanting allows better penetration of roots in the soil and better shoot development. The main field is appropriately ploughed and manured. When the seedling is 4-5 leaved, transplanting is done. During transplanting, proper distance is kept between plants and rows to enable the plants to receive sufficient sunlight and water.

Irrigation

Roots fail to develop and elongate in a dry soil. Therefore, for the very survival and proper development of plants, irrigation is necessary. The crop is irrigated according to its water requirements and soil characteristics. Irrigation is necessary during the seedling, tillering, flowering and grain filling stages of the crop.

Drainage

There should be provision for draining the excess of rain water. The rice crop tolerates standing water in the field, while in other like maize and vegetables the excess water must be drained out.

In order to learn the different agricultural practices, you must visit the nearby agricultural farms or vegetable gardens. This will give you a lot of fun and you will learn much.

Control of Weeds, Pests and Insects.

You must have noted it with great disgust that along with plants you grow, unwanted plants also come up, as if from nowhere. These weeds deprive the crop of

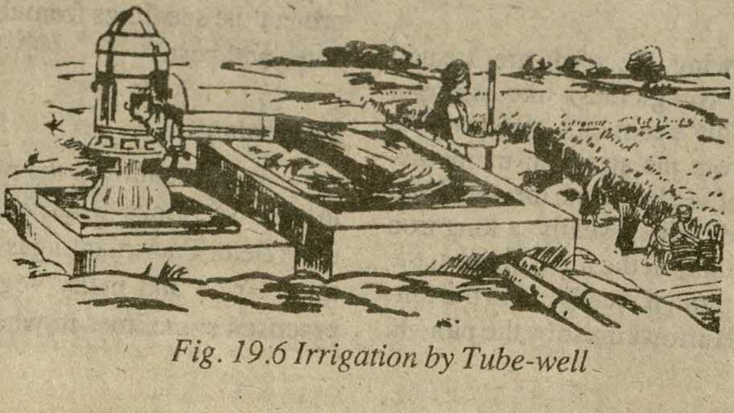


Fig. 19.6 Irrigation by Tube-well

Fig. 19.7. Crop protection.

part of the plant food and hinder the growth of useful plants by causing overcrowding. It is, therefore, absolutely necessary to remove the weeds.

Manual removal of weeds is, both, very slow and cumbersome. Chemistry has stepped in to help us in removing the weeds and in preventing more weeds to establish in the field.

It has provided us with certain chemicals which destroy weeds without harming either the useful plants or the men who apply them to the fields. Such chemicals are called *weed killers*.

One of the simplest weed killer that has been in use for a very long time is kerosene. It effectively destroys weeds from vegetables like carrots, coriander (*dhania*) and fennel (*sounph*) crops.

Calcium cyanamide, $CaCn_2$, is used as a weed killer in the onion fields.

Among the more recently discovered weed killers is 2, 4-dichlorophenoxyacetic acid, usually shortened to 2, 4-D. It is extremely effective and is applied in solution.

It is not harmful either to men or animals.

Many other weed killers, though highly effective, do produce some harmful effects on domestic animals and birds.

Pesticides and Insecticides. According to an estimate, four rats eat up as much grain as one man and destroy another equal quantity by making it unfit for human consumption. It is further estimated that the rat population in our country is nearly four times the human population. Obviously, if we could save the loss caused by these pests, each person could have nearly two or three times the food he is able to obtain from our own resources. Locusts and many other types of insects also cause considerable damage to the crops.

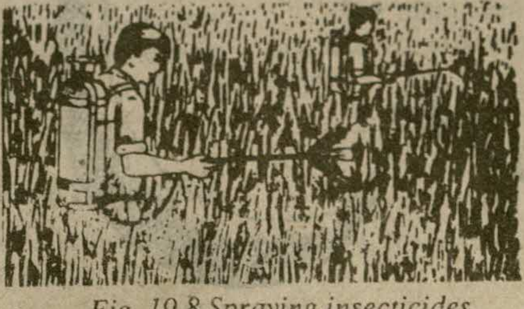


Fig. 19.8 Spraying insecticides.

Chemistry has created a number of substances that kill pests called *pesticides* which means pest-killers. Zinc phosphide (formula : Zn_3P_2) is widely used for killing rodents and for this reason is often called a *rodenticide*. DDT (Dichlorodiphenyl trichloroethane, and BHC (Benzene hexachloride) are useful pesticides. Gammexane is an insecticide to kill insects.

Parasites which damage the leaves of plants are destroyed by spraying with a suspension of Paris green in water (2 grams per litre). Paris green is a complex compound containing copper and arsenic; the chemical name being cupric arsenite-accetate.

Sodium hexafluosilicate, Na_2SiF_6, and other fluoride preparations are used for killing cereal parasites. These preparations are sprayed on young plants in the form of fine powders.

Protection of Plants from Diseases

Plants are attacked by many diseases which arrest their growth and spoil their leaves, fruits, etc. Such diseases are often caused by fungi. The chemical agents that destroy the fungi and thereby protect plants from diseases are called *fungicides*. Some of the *fungicides* in common use are :

1. *Bordeaux mixture*. It is a bluish-green suspension obtained by mixing equal volumes of 1 per cent solution of each of copper sulphate and milk of lime. It is used for spraying apple trees and grapes vines.

2. *Formation*. It is a water solution of a compound, called formaldehyde. It is used for treating the seeds before sowing them. The resulting plants are resistant to diseases.

3. *Sulphur dioxide*. This is produced by burning sulphur in air and is a powerful fungicide. It is also used to fumigate special store houses.

Harvesting, Thrashing and Winnowing

Very often one sees the wheat and paddy fields, pale yellow or golden in colour at the end of their season of cultivation. One wonders what has happened to the same fields which were green some time back. This change in colour is due to the maturity of the crop which is ready for cutting (harvesting). Most of the crops are removed or harvested close to the ground with the help of a Sickle. We have observed huge machines (combiners) doing both harvesting and separation of the grains from the chaff (thrashing). Animals are also used on a large

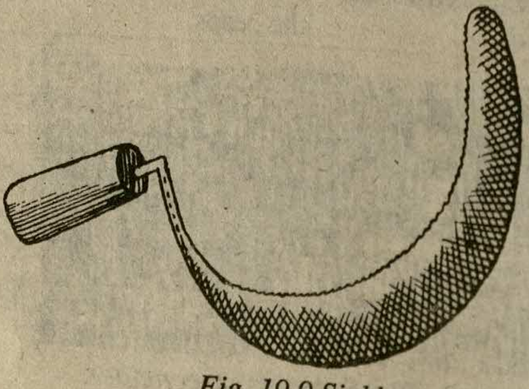


Fig. 19.9 Sickle.

scale for this purpose. In addition to bullocks and buffaloes, sometime camels are also made to walk over the harvested dried crop. After having the stems of the plants cut to small pieces (*hay*), the grains are separated from chaff by winnowing.

Storage

In order to dry the grains they are spread on the open for some time and then stored in gunny bags.

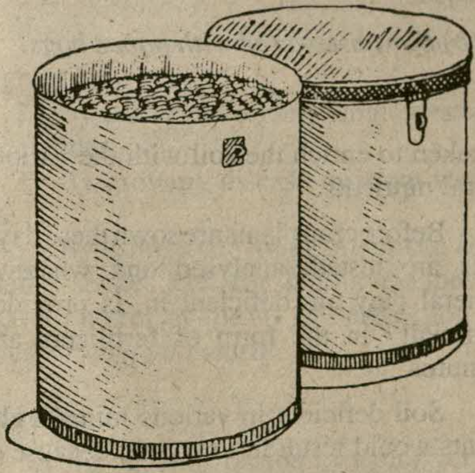


Fig. 19.10 Bins for storage of grains.

Properly ventilated, cemented halls called godowns are used for storing foodgrains in large quantities. Small boxes of mud or metal (bins or granaries) are used by some farmers to store the grains. Protection of grains from insects and rats is possible by storing them in such manner. Low temperature also helps in storage. Some fruits and vegetables are stored at low temperature (cold storages).

19.3. Improvement of Crop Production.

We have seen that man is directly and indirectly dependent upon the various types of crop plants.

Therefore, man has been trying its utmost to improve the crop plants in various respects as given below :

1. To produce many varieties of crop plants, for example :
   (*a*) Different varieties of wheat like Kalyan Sona, Desi, Sherbati and Heera Moti etc.
   (*b*) Different varieties of rice.
   (*c*) Different varieties of mangoes, apples etc.

2. To produce crop plants with increase in its yield.

3. To produce disease-resistant varieties so that they are not infected by bacteria and fungi etc.

4. To provide them with better and enriched soil.

5. To improve upon the irrigation facilities.

6. Lastly, improving the ways of storing the crop products to keep them free from pests.

The question now arises as to how the man has been successful in attaining the results to improve upon the crop production.

There are various means of improvement of crop production followed by man as given below :

Breeding

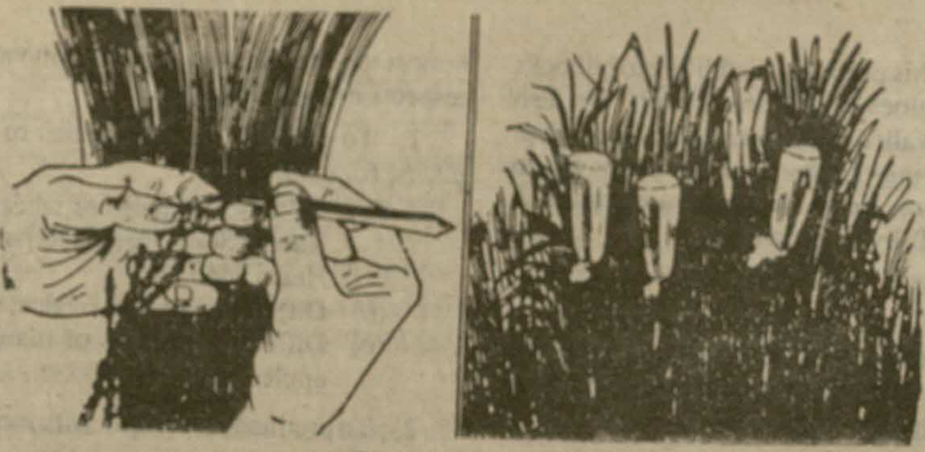
A very common technique used to improve the crop plant is called *Breeding*.

The main aim of the technique is to produce a new crop superior to the existing crop.

The new crop thus produced is called a *variety*.

Following are the steps involved in bringing about the phenomenon of breeding :

1. Crop plant with desired characters are selected.



Breeding Technique

(a) Removing another with the help of a phorcep

(b) Flower covered with paper bags.

Fig. 19.11

2. Such desired plants need to be *crossed* as follows:

(*i*) In a mature bisexual flower the anthers are removed manually.

(*ii*) This flower is covered with a polythene bag to avoid self-pollination.

(*iii*) After a few days pollen grains from a desired crop plant are shed over the flowers from where anthers were removed.

(*iv*) The pollen grain (containing male gamete) of one type of crop plant fuses with the ovule (containing female gamete) of the other plant. This is called *cross* between the two varieties by *hybridization* method.

The new crop plant produced from the seeds of the above crossed plants is a hybrid.

Hybrid thus produced always shows better results.

Hybridization can also help in producing disease resistant varieties.

Soil

We have studied in the lesson of soil; soil is the only source of reaching mineral nutrients to the plants. Therefore, care should be taken to enrich the soil with the various useful nutrients.

Before crop plants are sown these days, soils are tested, analysed and whatever mineral they are deficient in, is provided artificially in the form of fertilizers and manures.

Soil deficient in various mineral elements would result in low yield because of poor growth of crop plants.

You know different components of soil have different water holding capacities. Different crop plants need different quantities of water. Therefore, it must be seen that proper components should exist in the soil.

By analytical studies of soil, it has been observed that soils may be acidic or alkaline. Different crop plants need different type of soil. By adding sodium nitrate we can make acidic soil alkaline. So, artificially, we can change the nature of the soil as required.

Common fertilizers used these days are NPK (Nitrogen Phosphorus and Potassium).

CAN (Calcium Ammonium Nitrate).

Fertility of the soil can be increased by inoculation of the soil with *Rhizobium* bacteria.

Plant Protection

Most of our crop plants get spoilt by various pests like grass-hopper, rats, squirrels etc.,and disease caused by bacteria and fungi.

To get the high yield from crop plants, it is essential to keep them away from these hazards.

The best ways of protecting them are as given below :

1. By use of pesticides, fungicides and insecticides.
2. By growing disease-resistant varieties.
3. By using some living organisms like lizards, snakes etc., for killing the pests. Such a control or means of protection is called *Biological control*.

Irrigation :

A lot depends on the irrigation techniques for getting good yields from the crop plants in quality as well as quantity. Most of our crops get spoilt because of failure of rains.

Irrigation methods can be improved by installing tube wells, using different types of pumps and pistons, which may help in irrigating the fields.

19.4 Animal Management

Since the dawn of history, man has been domesticating animals in order to use them for work and for food. In the process of domestication, he has been developing methods for his care, for his feeding, and for getting the better breads. For a long time, man has been raising the kinds of animals he wants. For example, dog has been a companion of man for a long time. The animals he raised were livestock like cattle, sheep, pigs and poultry. This knowledge, in course of time, has developed into the science of animal husbandry.

Importance of Domesticated Animals

India is a predominantly agricultural country. Livestock, such as cattle, sheep, goat, camel, horse, pig and fowl play an important role in rural economy of India. On the basis of utility, the livestock can be categorised into :

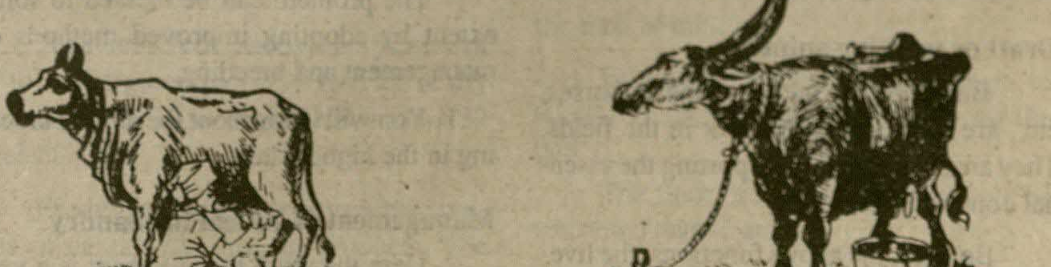


Fig. 19.12 Milk giving animals.

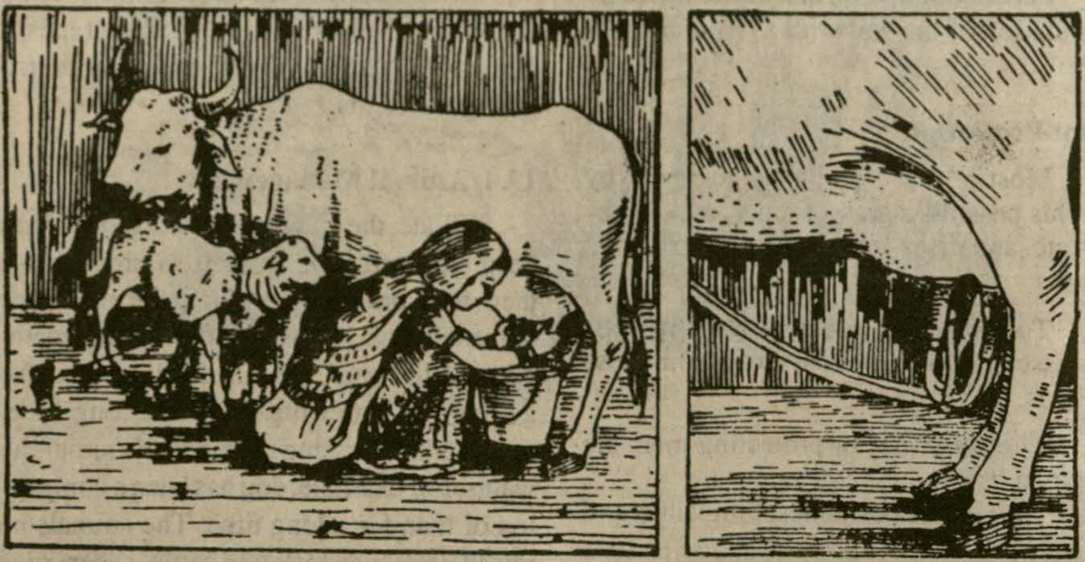


Fig. 19.13 Milking of animals.

Milk giving animals

Cows, buffaloes and goats provide us with milk. Milk is a perfect natural diet. Milk and its products like curd, cheese, ghee and butter are good food.

Meat and egg-giving animals

Ducks, fowls, pigs, sheep and goats are the main sources of meat. The poultry also provides us with eggs. Sheep is also a source of wool.

Draft or working animals

Bullocks, buffaloes, camels, horses, etc., are used for doing work in the fields. They are also used in transporting the essential commodities.

Besides, the above functions, the livestock provide with horns, leather, skin and feather, and their droppings and urine are used as manure to enrich the soil fertility.

Handicaps in animals husbandry

The main handicaps in the promotion and growth of livestock industry in India are :

1. Adverse climate and environmental factors.
2. Poor potential of the majority of the livestock to give good yield.
3. An actute shortage of feeds and fodders for the animals.

The problem can be tackled to some extent by adopting improved methods of management and breeding.

You will learn about the animal breeding in the higher class.

Management of animal husbandry

Here the word management is a very wide term and includes feeding, mating, providing drinking water and treating the sick and diseased animals.

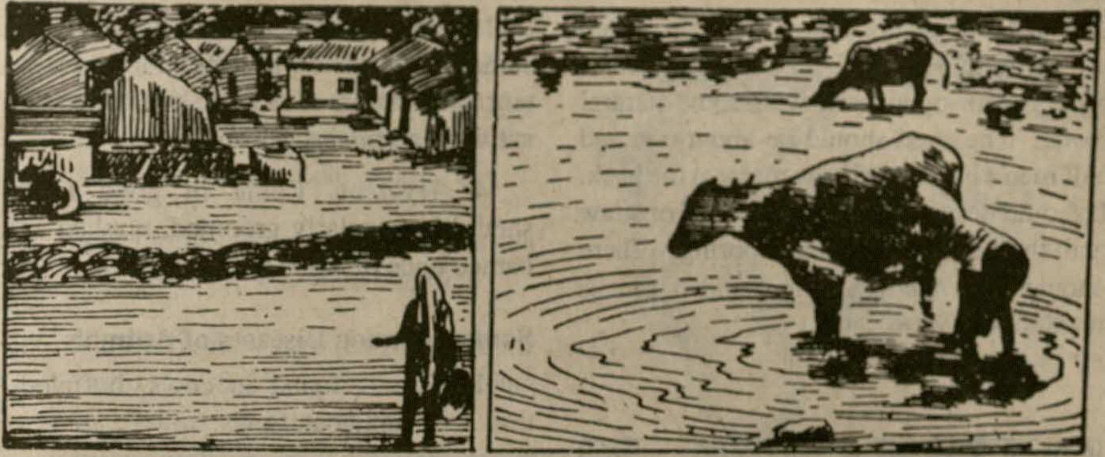


Fig. 19.14 Keeping and cleaning cattle in a village.

1. **Feeding**. Proper feeding is very important to make the inherited qualities effective. 'The cattle feed must be rich in nutrients. It should comprise carbohydrates, fats, proteins and minerals. The cattle feed may be divided into : (1) roughages, (2) concentrates.

(*i*) **Roughages.** They include the straws of cereals. They are fibrous, coarse and of low nutrient contents, in general.

(*ii*) **Concentrates.** They include cottonseed, oil-cakes, cereal grains, bran etc. They are rich in one or more of the nutrients.

An average cow needs a daily ration of 15 to 20 kg green fodder, 4 to 5 kg of dry grass, a good amount of grain mixture and 32 litres of water.

Feeds given to the poultry chiefly consists of cereals, or their by-products. The modern feeding for the poultry is the all mash diet. It is a mixture feed.

Sheep thrive on natural grasses, herbs, and farm wastes. They are generally not given any grain except when they are to be fattened for meat. Pigs should be given feed of comparatively low fibre contents such as cereal grains and their by-products.

2. **Housing.** To get the maximum production from animals, it is necessary to provide them protection from excessive rain, heat and cold. The cattle should be housed in comfortable, sanitary and well-ventilated house. Drinking water should also be made available to them. There should be proper drainage system and arrangements for the waste removal.

It may be good, if the calves are kept separately and brought to the cows only at the time of milking.

Bull shed should be large enough to allow free movement and exercise for the bull.

The floor of the cattle shed should be cemented and clean.

Sheep and goats do not require any special housing arrangement. They can be kept in an open yard fenced with dried thorny hedges and partially covered with thatched roof.

Pigs should not be kept in overcrowded and damp houses. Each shed should preferably have an open yard with some natural shade. The shed should be about one and half metre in front and one metre at the back. It should be made of bamboo, wood or straw and should have wooden flooring. There should be a feeding trough and it can be made of old water tank.

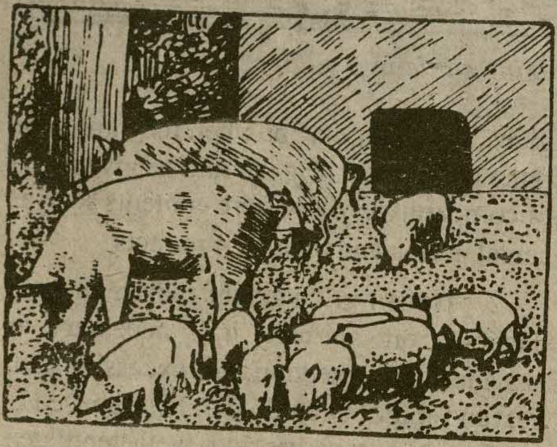


Fig. 19.15 Shed for pigs

For poultry, large permanent houses of different sizes, portable, solid-floor colony houses, or brick houses may be made. A floor area of half a sq. metre should be allowed for each bird.

In the poultry farms, these days, hens are made to lay different types of eggs. They may be fertilized egg or they may be unfertilized. Usually, the eggs sold in the market are unfertilized *i.e.*, they will not be able to hatch to produce chicks.

3. **Water and Water Supply.** Pure water in sufficient quantity is an indispensable necessity. The amount of water consumed by animals will depend to some extent on the nature of its food, size, functional activity and on the season.

4. **Hygiene.** Cattle in good health should be regularly groomed, washed and bathed once or twice a week.

Some Common Diseases of Animals

1. Pox is found in cows, buffaloes, sheep, goat, fowls.
2. Dermatitis is found in goats and sheep.

Diseases caused by Bacteria and Fungi

1. Tuberculosis : cattle, birds.
2. Fowl cholera.
3. Contagious bovine abortion.
4. Calf Diphtheria
5. Necrosis of feet and tail.
6. Diarrhoea of chick.
7. Foot rot of sheep.
8. Foot and mouth diseases of cattle.

Miscellaneous Diseases

In addition to these, there are several other diseases found in animals.

Many of these diseases can be controlled by using sanitary measures, controlling diets and keeping the animals comfortable. Animals should be given vaccination at younger age.

There are other animals too managed by us.

1. Honey bee keeping for honey and beewax is very popular among these days.

Recently, artificial apiary is set up in the gardens, where honey bees form their bee-hive. Later, the honey is extracted and bee-wax is used for seals, polishes, candle making etc.

2. Silk moths are reared as they provide silk fibres for silk dress material.

3. Similarly, fishes are reared in aquatic farms for various purposes of food, hide (skin) etc. Interestingly, fish liver oil is a rich source of Vitamins A and D.

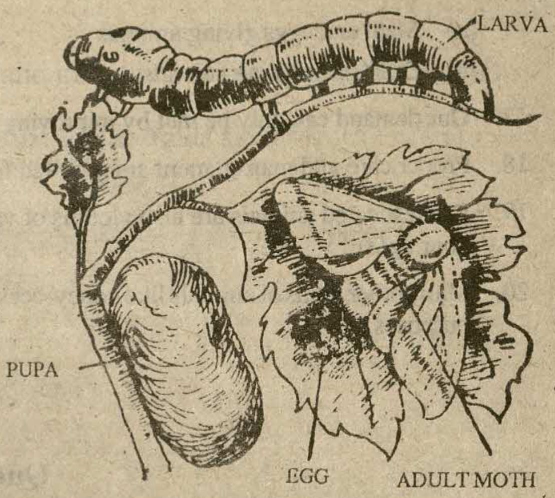


Fig. 19.16 A silk worm moth

Summary

1. Plants and animals, directly useful to us, need to be managed by us.
2. There are plants and animals managed by nature in jungles, forests, oceans etc.
3. Man has improved agricultural practices. The improvement is still continuing.
4. Crop rotation restores the lost fertility of the field.
5. Transplantation allows better growth of plants.
6. Fungicides and Pesticides are sprayed on the plants to protect them from some diseases and pests.
7. Good soil (Loam) need to be used for the plants.
8. Soil is the only source of mineral nutrition for the plants.
9. Irrigation facilities should be improved to get better yield from the plants.
10. Drainage system should be good, to prevent stagnation of water.
11. Good care should be taken, while sowing the seeds.
12. Harvesting, thrashing and winnowing are the practices, when the grains are full matured.
13. Grains need to be stored very efficiently.
14. Crop plants can perform better, if soil, irrigation, protection and young seedling plants are taken good care of.
15. Man has domesticated animals from very very long time.
16. Animals we need are:
    (*i*) Milk giving animals

(*ii*) Meat and eggs giving animals

(*iii*) Draft on working animals.

17. Our demand can only be met by improving the livestock.
18. Proper care and management are required for improvement of livestock.
19. Domesticated animals are also victims of various diseases. Animals should be given vaccination at your ages.
20. Many other kinds of animals like honey-bees, silk-moths and fishes are also managed by us for various purposes.

Questions

1. Make a list of animals you manage or you have seen people managing. Give utility of those animals.
2. Make a list of plants grown around you, and mention their utility to us.
3. Make a list of plants and animals managing on their own.
4. Name the common pesticides.
5. How do you think, grains should be stored ?
6. What are the steps to be taken for proper irrigation ?
7. Make a list of the various agricultural practices.
8. Define the following terms :
   (*i*) Harvesting (*ii*) Tilling (*iii*) Winnowing
   (*iv*) Thrashing (*v*) Transplantation (*vi*) Hybridization.
9. Make a list of the ways, people are trying to improve their crop plants.
10. What are domesticated plants?
11. On what basis is the livestock categorized ? Explain.
12. Explain the different steps involved in the management of livestock.
13. Why it is essential to keep the hygiene of livestock in mind ?

14. Name some domesticated animals and give their utility to mankind.

15. Write the names of diseases, the following animals suffer from :

    Cattle, Fowl, Calf, Goat, Chick.

16. Do you think the eggs you get in the market can give you chicks ?

Activities

1. Make charts for the class, explaining :
    - (*i*) Management of domesticated animals
    - (*ii*) How to improve the cultivation of crops ?
    - (*iii*) Agricultural practices.
2. Ask your teacher to arrange trips to :
    - (*a*) The farms
    - (*b*) The poultry farms
    - (*c*) Cow sheds
    - (*d*) Honey-bee culture places etc.

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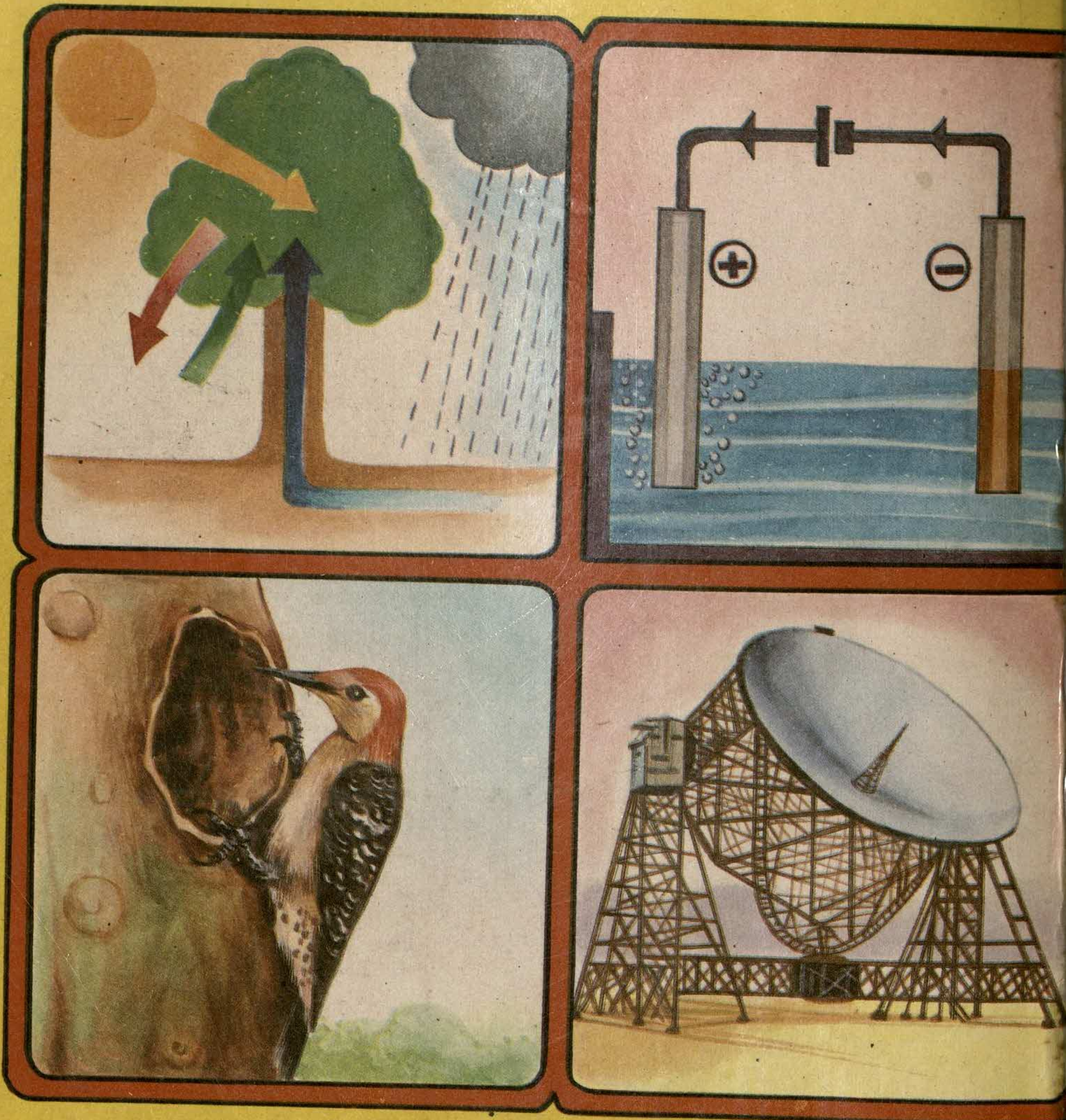
BASED ON THE NEW EDUCATION POLICY



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